The Journal of Electricity, Power and Gas.

Devoted to the Conversion, Transmission and Distribution of Energy.

VOLUME XVI. SAN FRANCISCO, CAL., MARCH, 1906. NUMBER 3

The Gas Producer Power Plant.

BY C. B. LAMONT, M. E.

BY an act of Congress, approved February 18, 1904, and in the General Deficiency Bill approved April 27, 1904, the sum total of $60,000.00 was appropriated "For analyzing and testing at the Louisiana Purchase Exposition the coals and lignites of the United States, in order to determine their fuel values and the most economic method of their utilization for different purposes, under the supervision of the Director of the United States Geological Survey * * * Provided, that all testing machinery and coals and lignites to be provided shall be contributed without charge to the Government."

That the results of the above authorization will be of greater value than even the most sanguine can predict is self-evident upon a careful study of the reports, and of the conditions affected. There is no state in the Union where coal is not used to almost an exclusive extent for industrial purposes. Exceptions, of course, to districts immediately adjacent to large supplies of cheap fuel oil and a high priced coal.

The results sought for in the investigations of this testing plant constructed at St. Louis, and still in operation, were, primarily, the comparison of mechanical value of a coal as used in a typical stationary steam plant and its performance under a corresponding gas producer gas engine plant. The committee in charge, Messrs. Edward W. Parker, Joseph A. Holms, and Marius R. Campbell, all men of marked ability, were ably assisted by the best mechanical talent, together with theoretical and commercial engineers. The results are authoritative.

Without going into the details of the work incidental to the methods of sampling both at the mines and from the cars, the numerous ultimate analyses, the investigations as to the adaptibility for briquetting, the washing methods, and many interesting details extraneous to our immediate subject and concerning ourselves solely with the behavior of bituminous coals and lignites under the steam test and under the gas producer test, we will for a moment examine into the general equipment for this branch only.

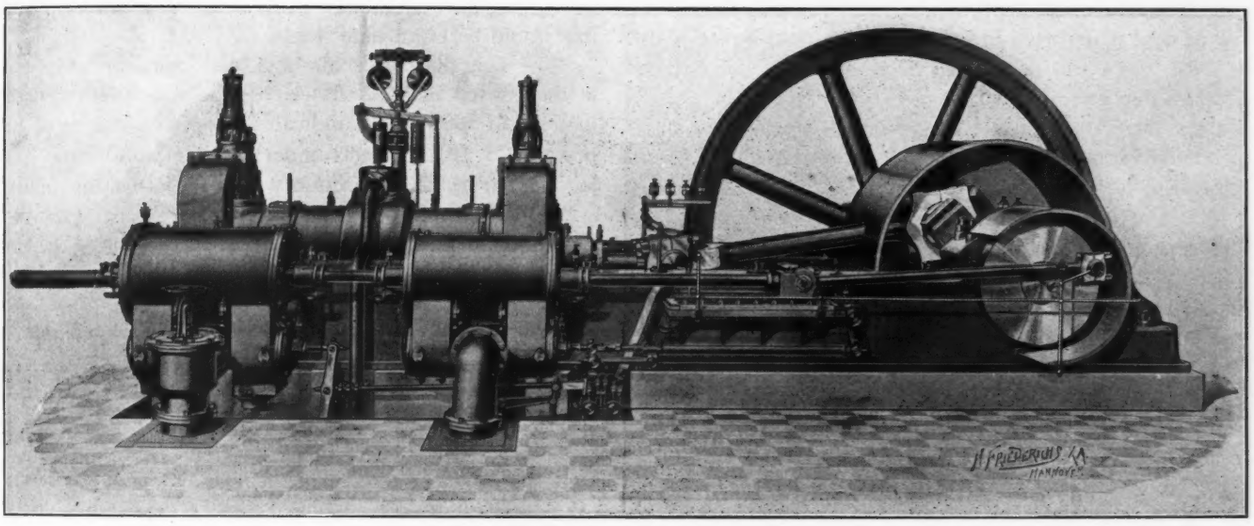


FIGURE 1. FIVE HUNDRED HORSEPOWER DOUBLE ACTING GAS ENGINE

The steam plant consisted of two Heine water tube boilers, 210 horsepower each, natural draft. One Allis Corliss engine 22-inch diameter by 42-inch stroke, 80 revolutions per minute, belt connected to a Bullock Electric generator. One Frost fire tube boiler of 100 horsepower, and a fifty horsepower slide valve engine.

The gas producer plant consisted of one Taylor gas producer, No. 7, with complete outfit for scrubbing and purifying gas. One Westinghouse gas engine of 235 brake horsepower, three-cylinder vertical single acting, 19 inches diameter, 22 inches stroke. One Westinghouse electric generator belt connected to the gas engine.

The reports as published to date show only results

achieved in the period from September 1, 1904, when the plant was put in operation, until December 22, 1904.

Right at this point the writer feels that he cannot do better than to quote verbatim from the preliminary report of this committee as follows:

"Among the results already clearly indicated by these preliminary tests the following may be stated as worthy of special consideration:

"1. The tests in the steam boiler plant of sixty-five carload samples of coal from seventeen states indicate the high steam-producing capacity of American coals, and that the quantity of many of these coals may be improved by washing.

"2. Most American bituminous coals and lignites can be used as a source of power in a gas producer plant.

"3. As indicated by comparative tests of bituminous coals from nine states, *the power efficiency of these coals when used in the gas producer plant is two and one-half times greater than their efficiency when used in the steam boiler plant,* or, in other words, one ton of these coals used in a gas producer plant has developed, on a commercial scale, as much power as two and one-half tons of the same coal when used in the ordinary steam-boiler plant.

"4. Some of the lignites from undeveloped but extensive deposits in North Dakota and Texas, when tested in the gas producer and gas engine, have shown unexpectedly high power-producing qualities, such as promise large future developments in those and other States.

"5. Some of the American coals, and the 'slack' produced in mining these coals, can be briquetted on a commercial basis.

"The value of the results of these investigations is, of course, not limited to the coal-producing sections of the country, but extends through every State and Territory where coal or other mineral fuel is used as a source of power. Thus, in the New England States, no coal is mined, but in 1900 the steam power produced through the consumption of coal and used for manufacturing purposes in these States cost approximately $50,000,000. The development of this power through the more effective methods suggested by these investigations would mean a saving to the manufacturers in these States of $15,000,000 to $20,000,000 per annum.

"As another illustration of the way these investigations may influence the affairs of the Nation as a whole, it may be stated that there were used in the naval vessels of the United States in 1903 approximately 500,000 tons of coal, costing $2,500,000. If the future gas producer and gas engine can be substituted on our battleships and cruisers for the existing steam engines and boilers, the saving in the cost of coal would not be less than $1,000,000 per annum, or, what would be of far greater importance, the distance traversed by each ship without coaling would be more than doubled.

"The fact that the coals and other mineral fuels used in the United States in 1904 cost the consumers approximately $1,500,000,000 indicates the magnitude and importance of the problems under investigation by the Geological Survey in connection with its coal-testing plant."

"Under the heading 'Comparison of Results Obtained from Steam and Producer Gas Tests' we note the following:

COMPARATIVE SUMMARY OF THE LEADING RESULTS OF THE COAL TESTS UNDER THE BOILER AND IN THE GAS PRODUCER.

Name of Sample	Duration of Trial.		Total Dry Coal Consumed Per Hour (a)		Dry Coal Burned Per Square Foot of Grate Surface Per Hour		Water Evaporated from and at 212° F. Per Pound Dry Coal.	B. T. U. Per Pound Dry Coal Used.		Electrical Horsepower Delivered to Switchboard.		Total Dry Coal Per Electrical Horsepower Per Hour (a)	
	Steam Plant	Gas Producer Plant	Steam Plant	Gas Producer Plant	Steam Plant	Gas Producer Plant (b)	Steam Plant	Steam Plant	Gas Producer Plant	Steam Plant	Gas Producer Plant	Steam Plant	Gas Producer Plant
	Hours	Hours	Pounds	Pounds	Pounds	Pounds	Pounds					Pounds	Pounds
Alabama, No. 2	10.02	43.00	874	328.7	21.54	7.78	8.55	12,555	13,365	213.7	200.6	4.08	1.64
Colorado, No. 1	9.97	30.00	722	341.7	17.80	7.56	7.21	12,557	12,245	149.1	200.2	4.84	1.71
Illinois, No. 3	10.13	30.00	861	356.7	21.23	8.41	8.04	12,857	13,041	198.1	199.6	4.34	(c) 1.79
Illinois, No. 4	10.02	30.00	938	348.5	23.13	7.96	7.27	12,459	12,834	195.4	198.4	4.80	(c) 1.76
Indiana, No. 1	9.93	29.67	908	384.3	22.39	9.08	8.45	13,377	13,037	220.0	199.9	4.13	(c) 1.93
Indiana, No. 2	10.13	7.00	832	312.0	20.51	7.13	8.02	12,452	12,953	191.0	201.0	4.35	(c) 1.55
Indian Territory, No. 1	9.75	31.00	778	374.0	19.17	8.95	8.64	12,834	13,455	192.3	204.0	4.04	1.83
Kentucky, No. 3	10.07	30.00	882	381.2	21.75	8.92	8.27	13,036	13,226	208.9	200.5	4.22	(c) 1.91
Missouri, No. 2	9.98	4.33	1014	339.6	25.00	7.96	7.08	11,500	11,882	205.6	198.6	4.93	(c) 1.71
West Virginia, No. 1	9.98	24.00	768	315.6	18.91	7.36	8.95	14,198	14,396	196.7	200.4	3.90	1.57
West Virginia, No. 4	10.00	9.00	770	258.2	18.98	5.96	9.65	14,002	14,202	212.5	199.7	3.62	1.29
West Virginia, No. 9	10.00	6.33	721	320.1	17.78	7.60	10.09	14,616	14,580	208.2	201.0	3.46	1.59
West Virginia, No. 12	10.13	30.00	719	300.5	17.68	6.92	9 90	15,170	14,825	203.6	199.8	3.53	(c) 1.50
Wyoming, No. 2	9.95	30.00	1075	416.5	26.51	9.50	5.92	10,897	10,656	182.0	201.2	5.90	2.07

(a) In gas producer plant this includes coal consumed in the producer and the coal equivalent of the steam used in operating the producer.

(b) Coal actually consumed in the producer only.

(c) Gas hopper leaked during these tests.

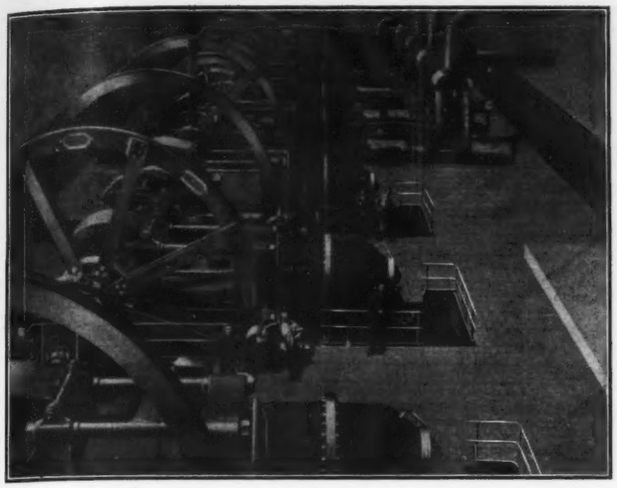


FIGURE 2. NINE 600 HORSEPOWER COCKERILL GAS ENGINES IN OPERATION AT DIFFERDANGE

The accompanying table, showing the comparative results of burning the various coals under the boiler and in the gas producer, is of much interest and value.

"It is to be recollected that the steam generated by the boiler was used in a simple non-condensing engine of the Corliss type, whose 'water rate' was 26.3 pounds of steam per hour per horsepower developed, that this engine was belted to the electric generator, and that the mechanical efficiency of this combination of engine and generator was 81 per cent.

"With these figures available it will be an easy matter to calculate the number of pounds of coal which would have been required to produce an electrical horsepower, provided a more economical type of steam engine had been used, or if the electrical generator had been directly connected to the engine, with the resulting advantage of a higher mechanical efficiency.

"If, for example, the steam generator had been used by steam engines operating in large units, it will be with 18 pounds of steam per hour, and if the engine and generator had been direct connected, giving as high a mechanical efficiency as 90 per cent, then the total dry coal per electrical horsepower would have been reduced from 4.3 pounds per hour to nearly 3 pounds per hour.

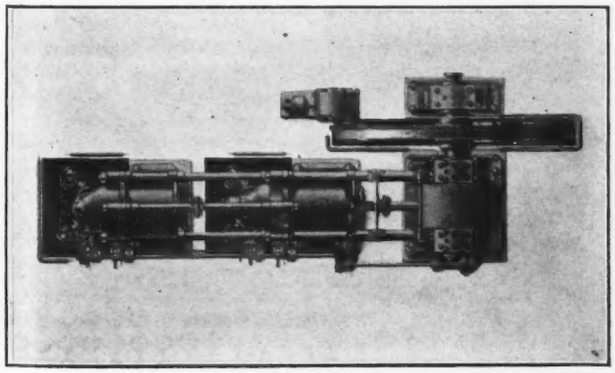


FIGURE 3. SIX HUNDRED HORSEPOWER GAS ENGINE FOR DIRECT COUPLING TO DYNAMO

"While these figures are frequently and easily attained by steam engineers operating in large units, it will be conceded that in plants of from 200 to 250 horsepower, they are but seldom reached.

"It should be mentioned that *the labor required would be the same for the operation of either the boiler plant or the gas producer plant of the capacity under tests.* In either plant two men would be sufficient.

"In considering the possible increase in efficiency of the boiler tests with a compound engine substituted for the simple engine used, the fact should not be overlooked that a corresponding increase in the efficiency of the gas producer plant may be brought about under most favorable conditions. The gas engine is passing through a transitional period. In the larger sizes the vertical single acting engine is being replaced by the horizontal double acting. Other changes and improvement are constantly being made which tend to do for the gas engine what compounding and tripling the expansion have already done for the steam engine.

"The gas engines used in the trials recorded is a vertical three-cylinder single acting engine with no means of

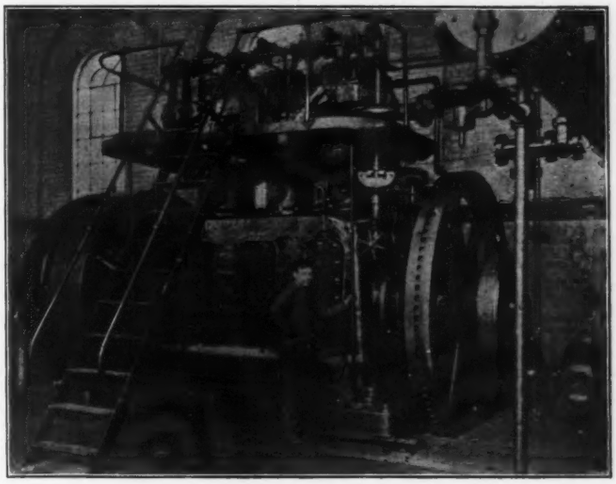


FIGURE 4.VIEW OF 250 HORSEPOWER WESTINGHOUSE SET

changing the ignition while the engine is running. A brief consideration of these points will lead at once to the conclusion that *the gas engine and the steam engine used in these tests compare very favorably,* and that any increase in efficiency in the boiler tests that might result from using a compound engine can be offset by the introduction of the more modern type of gas engine."

The writer has introduced the foregoing excerpts from the official report of the first recognized testing laboratory in the United States, if not in the world, devoted almost exclusively to the study of the action of any one coal as used in the typical stationary steam boiler plant, hand fired and natural draft, as compared with the behavior of the same coal under the gas producer plant, whose appurtenances and requirements are, as nearly as can be judged, on an even footing with the steam plant used.

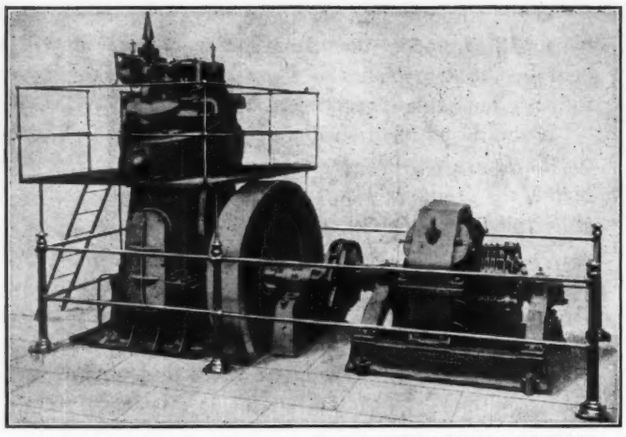


FIGURE 5. CROSSLEY'S DOUBLE CYLINDER INVERTED VERTICAL GAS ENGINE

America, *i. e.,* the United States, has lagged behind the European countries in their ready acceptance of the gas engine in large units and its adaptibility for commercial use. There is a common saying in the States, "Well, I'm from Missouri." We wonder if the paternal Government had that fact in mind when it located the first experimental laboratory on commercial lines in St. Louis, Missouri. If the Missourians are convinced surely it will not be long ere every engine handler as well as engineer will speak glibly of producer gas and as familiarly as he does today of steam.

The progress shown during recent years in the development of the gas engine bids fair to controvert the phophecy of Sir Fredrick Bramwell in 1881 in a paper read before the Engineering Section of the British Association, in which he stated that the time would come when gas engines would be known only to museums. Many of the largest industrial power stations in Europe today are using gas producers and gas engines to the exclusion of steam, and to this one item alone is the British shipbuilder to a large extent indebted, and enabled thereby to produce marine construction at a cost markedly below our own.

It is most fortunate that our own little testing plant at St. Louis *is small.* How often do we not hear in discussion of gas versus steam, "Yes, in large plants you may show results, but in small ones—"

As we review the field of development of the steam engine during the past century, we can but regret that had the energy, thought and engineering skill that has been brought to bear on the development of steam and its application to motive power been expended on the corresponding development of the internal combustion engine, even the fanciful imagination of the aeronaut would not have been in vain.

To the student of thermodynamics, the bold statement alone that a thermal efficiency of the gas engine of 40 per cent has been achieved is enough to set his mind agog with prognostications for the future—yes, and for the present as well.

The recent progress in gas engine construction has gone forward in leaps and bounds, and larger and larger units are being installed throughout the world. There are many gas engines in daily service of over 2000 horsepower, and many manufacturers equipped to build engines of 5000 and even greater horsepower. It is only a question of time when the United States will lead the world in its manufacture of large units of gas engines and producers.

The trend to-day is toward the large unit, the horizontal rather than the vertical, double acting rather than single acting, the making of all parts rigid, the addition of heavy frames, ties and girders, heavier bearings, brackets and points of wear and stress, water cooling of pistons as well as jackets, additional air cylinders for providing a blast of clear air for scavenging purposes, the use of mushroom valves, of pilot valves in conjunction with the main exhaust valves, and the use of electric spark for ignition purposes.

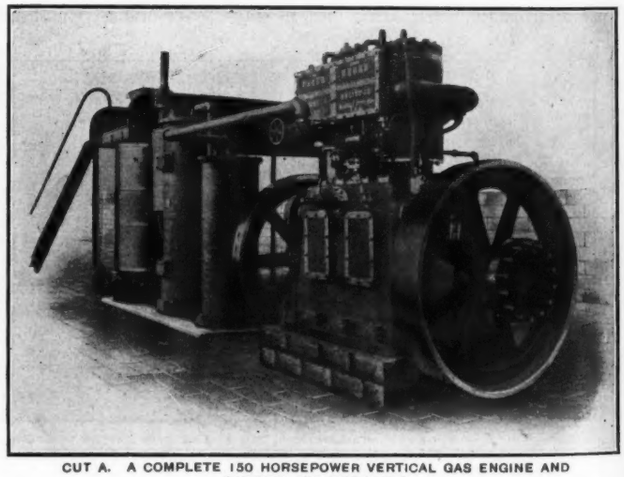
In this connection we might state that the method of "breaking a current at its maximum strength, supplied by a shuttle armature oscillating between permanent magnetic coils" is held by Continental authorities more desirable than our two best known forms of "jump spark" and "make and break."

The problem of government of speed is one which has been successfully met and overcome and perhaps more thoroughly solved by the cutting off of the supply of mixture of gas and air at various points in the suction stroke.

The starting of the gas engine in large units is now most commonly accomplished by the introduction of compressed air, one or more cylinders being supplied, and the others cut in with gas as the engine is brought to sufficient speed. The "self starters" are rarely employed.

The 1000 horsepower and 4000 horsepower gas engines in the city of Cleveland, Ohio, are started by supplying the mixture under pressure from a pressure tank, as if it were simply compressed air, and then the sparking gears cut in one cylinder at a time.

Electrical engineers are now thoroughly convinced of the successful utilization of the gas engine in driving



CUT A. A COMPLETE 150 HORSEPOWER VERTICAL GAS ENGINE AND SUCTION GAS PRODUCER

not only direct current generators but alternating current generators operating in parallel as well.

One of the latest installations is the Warren and Jamestown alternating current single phase railway system, operating between Warren, Pa., and Jamestown, N. Y. The power station is equipped with two 500 boiler horsepower, double acting, horizontal, heavy duty type gas engines, directly connected to alternating current single phase generators. Fuel, natural gas.

One of the best informed of our British cousins, Herbert A. Humphrey, in a paper read before the Engineering Section of the British Association concludes his remarks on recent progress as follows:

"The governing of gas engines is in some ways superior to that of steam engines, as there is less risk of surging and hunting, but with gas engines for alternators in parallel, the governors should possess singular characteristic curves and degrees of stability. The margin of speed between no load and full load should not be too narrow, never less than 3 per cent. A change which means the replacing of boilers and steam engines by gas producers and gas engines, and is accompanied by a saving of more than half the coal cannot be averted. Moreover, by the 'Mond' process the gasification of a ton of coal leads to the recovery of ninety pounds of sulphate of ammonia, worth eight shillings."

The writer has introduced a few cuts of typical installations of gas engines and generating sets. As has been previously noted, the tendency is now more decidedly toward the horizontal double acting engine. Its advantages commercially are a lower first cost with increased economy of operation.

The producer we have for a few moments overlooked in our discussion of the gas engine. Producers are now fortunately in a condition of development to require but little defense. They are being installed broadcast throughout the manufacturing world, and are being employed not only as a producer of gas for engine consumption, but for blast furnaces, foundries and many kindred industries.

There is one form of gas producer which has not as yet reached a generally recognized position as a commercial success. We refer to the suction gas producer burning bituminous coals and lignites. This field of investigation is not barren, however, and at a recent competition held abroad, there were sixty-two entries of this form of producer. The suction gas producer is now in practical use in small units utilizing coke, charcoal and anthracite coal. It forms a practical solution of many low-powered problems. For example a 50-horsepower charcoal suction gas producer and gas engine is capable of developing 350-horsepower on 240 pounds of charcoal, or, in other words, figuring charcoal at $5.00 per ton on a cost of less than 2-10 cents per horsepower hour. Such a plant is illustrated in Cut A.

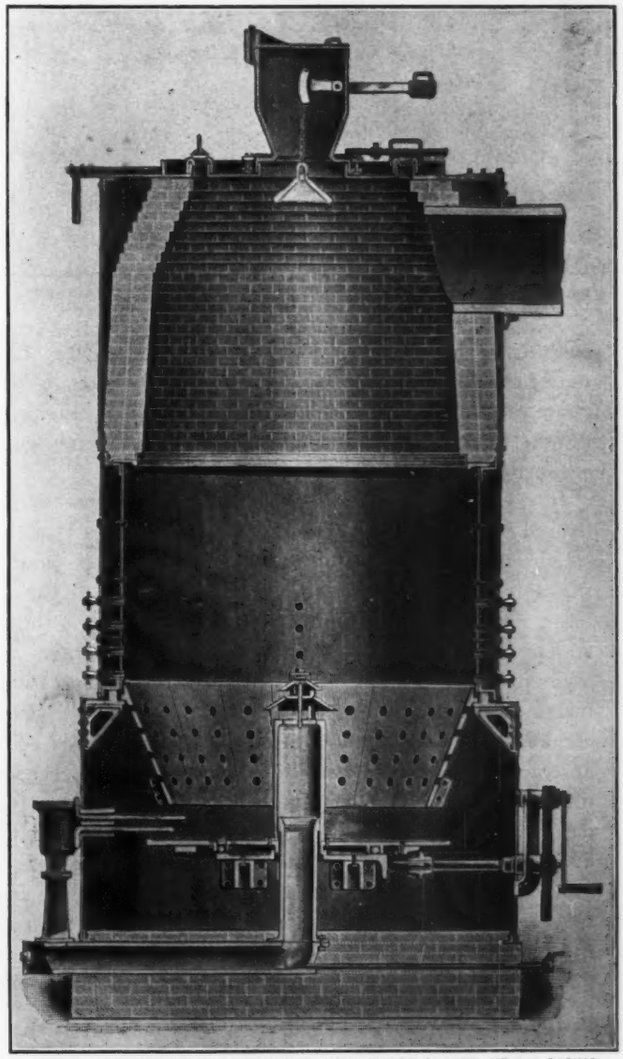
The type of gas producer in most common use for gas engine plants burning bituminous or lignite coals is shown in Cut B.

The cut shows an early type of hopper feed—the later installations contain sealing devices preventing the escape of the gases, as well as mechanical feeders or stokers for the uniform distribution of coal over the surface.

A common arrangement of producer, scrubber, economizer, tar extractor, storage tank, etc., is shown in Cut C.

A producer plant consists primarily of a furnace which permits the access of coal and the egress of gas—the usual grate bars, or revolving grates—the closed ash pit with forced draft connections for forcing air by a blower or steam jet through the body of the coal. In our cut shown (Cut C) the air is forced into the fuel through a conduit leading up through a heavy bed of ashes, and little or no attention is given draft through grate bars.

The producer may be wholly of brick, or partly, may be of steel water jacketed in whole or in part, or various combinations of the two. Conditions change the design. A water seal is sometimes fitted to the bottom. The coal is completely consumed in the producer, the resulting product being ashes and producer gas, with its accompanying by-products. The gas from producer is led

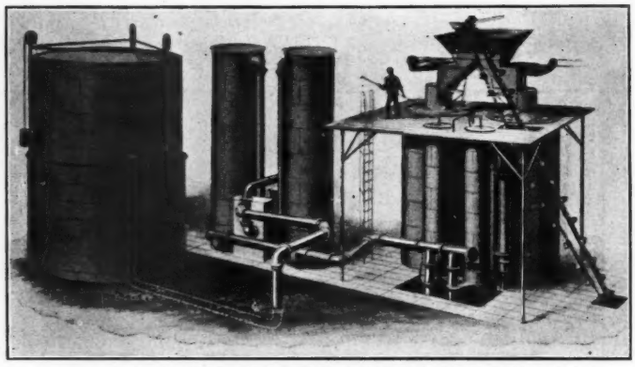


CUT B. THE TAYLOR GAS PRODUCER, HALF WATER JACKET, UPPER CASING

through an economizer usually. This is of various forms and its objects are chiefly to heat the air used in the ash pit or in mixture. The gas is then scrubbed, either in the usual manner as lighting gas is handled, or in a simpler form utilizing gas house coke.

From the scrubber to the tar extractor and to the purifier, the usual sawdust and iron filings for removal of sulphur, and finally to the holder or storage reservoir. In the suction producer, as previously noted, the holder is omitted and the "draft" or suction produced in the gas engine draws the gas from the producer through the intermediate stages to the engine.

We have mentioned heretofore the "Mond Gas." This is a development of Dr. Ludwig Mond. Clean gas is delivered from bituminous coal, and either with or without by-product recovery. "With by-product recovery the nitrogen of the coal is converted into ammonia with subsequent absorption in dilute sulphuric acid, forming ammonium sulphate. By evaporation, this solution yields



CUT C. FOUR HUNDRED HORSEPOWER ENGINE GAS PLANT DESIGNED AND CONSTRUCTED FOR THE ERIE RAILROAD AT JERSEY CITY, N. J.

crystals of the commercial 'sulphate of ammonia.'" One ton of coal can be made to produce ninety pounds of "sulphate of ammonia." It might be interesting at this point to note further the following statements made upon good authority relative to the "Mond Gas."

In the by-product recovery an excess of steam is delivered to the producer with the air blast. A part of this steam enriches the hydro carbons. The hot gas passing through tubular regenerators, giving up heat to the air blast, enters the washer, where it is cooled by intimate contact with water. The acid tower next extracts the ammonia from the gas, which entering the cooling tower meets a shower of cold water, itself cooled, its steam condensed, leaving a cold, clean gas ready for use. The abstraction of the sulphate of ammonia is not recommended for plants burning under thirty tons of fuel daily and when the necessary extra steam is not easily available. When we consider that we can expect to save 50 per cent. in fuel over the steam engine, and that further about $1.75 per ton may be gained by securing the by-products, the possibilities of the mammoth reduction in cost of power has not received the consideration and careful thought the subject deserves.

This example may be given: In a 2000-horsepower station-gas producer, gas engine plant, which would consume 8035 tons of coal per year (300 days of twenty-four hours each) there could be saved in the by-products on a basis of $1.78 per ton of coal gasified $14,300, or over $7 per horsepower. This saving is from by-products only and does not refer to the saving effected in comparative efficiencies of gas versus steam.

As a finale to this brief resume of the gas producer power plant it might be well to add a few words regarding the approximate cost of the steam plants and the gas producer plants.

If we consider a station of low power, say 200-horsepower or under, which would permit the use of such fuel as is practically accepted for the suction gas producer, the manufacturers of this type of machine are prepared to install the same at a first cost not greater than a good water tube boiler simple Corliss non-condensing plant. Its maintenance and depreciation are no greater than that of the steam plant and results show that the cost per horsepower hour can be reduced as much as 50 per cent. and in many localities more than 50 per cent.

The examination of a prospective gas producer and gas engine plant impresses us at once as being expensive in its cost of motor power as compared with engine alone of the steam plant, but we must remember that the engine of the steam plant is but a small percentage of the total cost, while the engine of a gas plant is a considerably greater proportion of the total investment. Further, the gas engine of today illustrates the law of costs governed by supply and demand. When we prophesy that within the next decade there will be ten times the present number of manufacturers engaged in the gas engine business we can safely state that the competition resulting will very materially reduce first costs on the article.

Basing our figures on Pacific Coast delivery and installation near rail or water transportation, the following will perhaps illustrate roughly the advantage to be derived from a purely monetary standpoint, and in favor of the gas producer plant.

Let us take a 2000-horsepower gas engine plant versus a 2000-horsepower steam engine plant, both installed and used for the generation of electricity, fuel—bituminous coal of about 12,500 British thermal units.

First—Gas producer Plant:

Three 750-horsepower units double acting horizontal gas engines, including freight, foundations, piping and erecting.....	$120,000
Three 500-kilowatt, 80-pole, three-phase, 2200 volts, 60-cycle, 90 revolutions per minute, revolving field, engine type, alternating current generators, complete with exciters, rheostats, switchboard, etc.....	25,000
Six water seal forced draft gas producers, complete with economizers, scrub-	

bers, tar extractors, purifiers, blowers, 150-horsepower steam plant, one 15,000 cubic feet steel gas holder, shafting, belting, coal conveyers, piping, foundations, erection, etc., etc..... 75,000

Making a total cost of plant erected...$220,000

Cost of producing a horsepower-hour based on 350 working days of twenty-four hours each, or 8400 working hours.

(Bituminous coal at $2.00 per ton)

2000 horsepower at one and one-half pounds per hour = 3000 pounds coal at $2.00 per ton, equals, per hour..... $3.00

Interest on $220,000 at ..... 5 per cent
Depreciation ..... 8 per cent
Insurance ..... 2 per cent
Repairs ..... 2 per cent

Total, per year .....17 per cent

Or per hour $\frac{\$220{,}000 \times .17}{8400}$ equals 4.45

Attendance.

One chief engineer, per day.....$ 5.00
One second engineer, per day..... 4.00
Eight attendants 16.00

Total per twenty-four hours....$25.00

Cost per hour 1.04

Total cost for 2000 horsepower per hour $8.49

Cost per horsepower-hour.....$0.004245

Second steam engine plant.

2000 horsepower water tube boilers, inclusive of freight, foundations, erection, forced draft appliances, conveyors, superheaters, economizers, mechanical stokers, piping, valves and fittings, pumps and auxiliaries..... $ 80,000.00

Three cross compound 750 horsepower each, Corliss non-condensing engines, including freight, foundations, erection, piping, auxiliaries, etc..... 85,000.00

Electrical equipment duplicating gas plant equipment 25,000.00

Total cost installed $190,000.00

Cost of producing a horsepower hour based on 8400 working hours per year. Assumed water rate of engine twenty-four pounds. Assumed-evaporative value of coal under boilers six pounds of water from and at 212 degrees F. for one pound of coal. Therefore four pounds of coal (approximately) for one indicated horsepower, 2000 horsepower x 4 equals 8000 pounds per hour at $2.00 per ton equals..... $ 8.00

Figuring total interest charges as previously detailed at 17 per cent we we have:

per hour $\frac{190{,}000.00 \times .17}{8400}$ equals. 3.845

Attendance.

One chief engineer .....$ 5.00
One second engineer 4.00
Eight firemen 20.00
Four coal passers 8.00
Four oilers 8.00

Total per twenty-four hours.....$45.00

Attendance per hour 1.875

Total cost per hour (2000 horsepower) $13.72

Cost per horsepower-hour equals $0.00686.

Or in other words the above figures show a saving of 40 per cent (approximately) in the utilizing of gas producer methods over steam.

Beyond question the steam plant may be refined—but at an increased cost, and consequently increased interest charges. The writer feels that the benefit of the doubt has been given the steam plant, and that its results shown are the very best average conditions, while the patrons of the gas producer power plant claim results far in excess of those shown for that class of plant, ignoring entirely advantages acquired by utilization of by-products.

POWER PLANT OPERATION AND MANAGEMENT.

BY H. SCHREIBER

ECONOMY and reliability of operation are the two most important points in power plant management, and much can be done to help by keeping this in mind in the original design. Adapting the size of the various units to each other and to the variations of the load, as well as consideration of the locations of the machines and of operating handles or valves require, for best results, a familiarity with the machines and methods and conditions of operation on the part of the designing engineer.

A switchboard arranged along a curved line instead of straight enables closer watch being kept on all panels, and when one machine is feeding one panel this will be of value, also when several feeders are on one machine or where it is desired to transfer from one machine to another, action can be taken more quickly when all panels can be seen from any one panel. Any one who has operated a long board arranged along a straight line would appreciate this, especially in cases of emergency. One plant using this type of board has rheostat hand wheels

punched in the center of the chord, some distance from the board, so all panels affected may be seen at once. Investigation of the station switchboard losses and of ground connections will often prove of interest when these losses are capitalized.

Oil guards and well designed reliable lubricating systems are always paying investments in medium sized and large plants. These may often be put in by the operating engineer using a small oil pump operated from some part of the engine or steam pressure from the live steampipes. A by-pass valve for removing all oil from the system in case of fire may be found to improve the insurance rating. Oil guards should be well made, neat and strong, as they often project in such a way as to come into frequent contact with those working around the machinery. A leaky guard is an abomination, making any one having to do with it disgusted with the whole thing. Brass trimmings help the wiper take pride in his work and result in a cleaner engine.

For fire protection around switchboard and generators all exposed cables may be soaked in sodium silicate or waterglass. If also wrapped in asbestos soaked in the same liquid they will be thoroughly protected by a hard fireproof and waterproof covering in addition to their original insulation. Those who have suffered from the effects of loose contacts, improper action of circuit breakers or lighting arresters appreciate what may result from overheated and unprotected insulation.

Sand is the simplest and cheapest thing to use for fires, but like the powders sold for this purpose it must be thrown on the base of the fire and therefore needs close contact with the fire to do the most good with the material at hand. Borax or ammonium phosphate, in long tin tubes or in some kind of a "popgun" will be found to be cheap and very effective, as they have a chemical action that sand has not. Of course where possible the portable liquid extinguishers are most effective, as with the use of the short tube and the pressure generated in the tank, the liquid can be easily directed to the base of the flame without approaching too close.

Around the plant shelves and bins should be provided so that there is no excuse for accumulation of dirt or scrap material or mixed up fittings, where there should be only useful fittings or tools. Names or pictures painted on the wall or bins where articles belong are permanent and do much to avoid careless arrangements. If a man knows where everything belongs he soon learns to remember what he has in stock, both tools and fittings, which may in times of emergency be quite important, as he knows at once what he has available.

Hand operated switches for grounding all lines in trouble or when not in use may save a lineman in case it gets crossed with a live line or when a sub-station man forgets or misunderstands his orders and connects it with his bus bars.

This simple device costs little and in more than one case would have saved a man's life. A danger signal hung on the panel that is not to be used or on a lever or hand wheel that must not be operated warns the operator that only the chief or engineer in charge has the right to take it off.

Along this same line it may be mentioned that signal lights placed on frames of generators and connected across the field terminals, though somewhat out of fashion, will warn the wiper to keep away when all is not clear. Rubberoid roofing rubber or wood floor mats in front of switchboard or around generators may save many times their cost.

Heating is sometimes a troublesome matter in a large water power plant, but where properly done it insures better attention to cleaning, oiling and other items that need constant attention. The use of air or water cooling the transformers is sometimes possible for this purpose. At other times it may be found to pay to use home-made electric heaters at times of light load.

Some large companies are now painting all their machinery white—principally on account of its effect on the public, though it has no small advantage in evenly distributing the light about the room and about the most inaccessible parts of each machine. A room filled with machinery painted white certainly presents a very pleasing appearance and must be very agreeable to the operating men. In cleaning up or when making repairs one lamp shows up better than two on a machine painted some dark color.

In the actual practical operation there are many little things which if closely watched will materially improve the economy of operation, as the use of steam heated waste cleaners and drivers, good steam heated oil fitters, regulation of feed and condenser pumps to the load, drips, draft, ashes, etc. For instance, a small pipe used on the boiler feed pump under ordinary conditions does not accumulate the water that the larger pipe usually installed does and which is usually throttled at the pump.

Maintaining at its maximum the ratio of capacity output to capacity operated, not only with regard to engines and generators, but to boilers and auxiliary apparatus will often be found to appreciably affect the total efficiency of the plant. Station records that will permit the chief to determine that this is being done cost little and take some little calculation, but they keep the men alert and enable the chief to keep closer watch of an important detail.

While an engineer may not always be judged by the care with which he looks after the details of maintenance and operation there is no doubt but that thoroughness in these respects show that a man has his job well in hand, and a man is not ready for promotion until he has mastered the details of his position and has time to see that they are all properly cared for.

Keeping a plant thoroughly clean is good in that it subjects all machinery to constant inspection for cleanliness if not for repairs. Moreover, keeping familiar with the details of his apparatus may oftentimes suggest to an engineer little changes or improvements of

value. Added to this, a clean plant is always attractive to good men and is an inducement to assist in keeping it in good repair.

A good plan to keep output records where automatic recording apparatus is not within reach is to mount the curve sheet in a case where it is arranged by clockwork to pass in front of a slot where there is room for the operator to make the necessary records as the sheet passes under it. In this way all data or curves must be recorded at the right time and cannot be filled in at the end of the watch.

If these records are made up in the form of curves at once and from them monthly summaries are made, valuable data as to actual operating load factor, total plant load factor and time and amounts of peaks will be available. In calculation of improvements needed these records form the most important data.

Experience quickly teaches how often each machine should be inspected or overhauled and how much wear to expect under given conditions within a certain time. Where the station record permits the actual time operated or output of any piece of apparatus to be determined, this forms a good basis on which to arrange regular inspections. With or without these records, however, it is wise where there is any considerable amount and variety of machinery in operation to arrange on a schedule the necessary routine work of inspection of various pieces of apparatus. Such a schedule will be found to be an excellent reminder for the head of each plant and a method by which the manager can check each inspection report as received so that he, too, keeps posted and knows that the work is done promptly. Careful reports made out in duplicate, covering inspections and repairs form valuable records of the history of each piece of apparatus and are of great interest when new machinery is needed. The duplicate copy passing under the manager's eye are filed under a card index system, where, if necessary, they may be cross filed or indexed so as to bring out any peculiar troubles or other points common to various machines. The duplicate detailed records also avoid the necessity of referring to any one's memory and keeps a company free of any tendency to biased judgment or changes in the force.

One of the most pleasing features of successful plant operations and management is an efficient and contented operating force. And to obtain this requires good judgment in selecting the men and much careful thought in handling them. An efficient and reliable man is seldom available when you need one, so it will be found wise to hire younger men capable of development and advancement, and a plant that has the reputation of caring well for its men and advancing them when possible usually has opportunity to pick its men. Favorable surroundings and wise encouragement will be found to do much to improve the men and keep them content.

While physical comforts, such as tubs and shower baths, especially in a steam plant, return many times their cost in better service, frequent or systematic holidays giving opportunity for mental recuperation will also be greatly appreciated by the good men.

An engineering club or benefit association under the company's control besides offering social and sick benefits and access to engineering papers, permits of helpful weekly meetings to discuss practical engineering questions as well as features of the operation of the company's system. This gives the chief opportunity to instruct his men and to lead them to base their opinions on right foundation principles rather than on what they have learned by hard knocks only. Many practical engineers go only to what they have personally seen and had hammered into them by hard experience and fear to go ahead trusting to abstract principles, which ordinarily is just as well, seeing that "a little knowledge is a dangerous thing," and what may appear alone to be correct, on wiser investigation will be found to be wrong. Under wise instruction men may be taught the right and sound principles of engineering and by a few illustrations be shown their practical applications.

Making them a part of themselves and of their stock in trade the engineer is in a position to use them, and he has learned in a half hour what otherwise may have taken months and much of the company's good money to teach him.

Where the extra list permits it is sometimes usual to give the men one day off in eight so that no one will be especially favored. Other plans are to work eight-hour shifts and changing the men to different shifts every month or two weeks as is convenient.

Under this arrangement the need of time for recreation is not so pressing as on the twelve-hour shift. Where during the absence of any one man his understudy is shifted up he is thereby given the opportunity to see at first hand the duties and requirements of his position as well as appreciate the value of a capable and efficient assistant. A wise man will under these conditions see his own shortcomings as well as ways in which he may improve on the methods or work of his superior.

Help men to look at their work in the right light, to appreciate the necessity of careful, intelligent and conscientious service; to see the value of a man that can be depended on—who is "there with the goods" in an emergency. A thinking man will wonder why things are as they are, an ambitious man will find out. As soon as he notes something new and is indifferent to it he is no longer progressing; and a man can not stand still, he must go either up or down.

Engineers, so called, have been found in charge of good sized plants who have never troubled themselves to inspect their apparatus except in cases of break-down. Naturally the first thing such a man would do in case of trouble would be to shut down, the last thing a good man would do who is intimately acquainted with his equipment.

Old plants, partly or entirely obsolete, are sometimes to be overhauled without interfering with the regular operation. Using part of the machinery to best advantage in the new plant and at the same time as it often the case, reorganizing the force, and you have a test that in many ways is far more trying and bothersome than laying out an entirely new plant.

A SYNOPSIS ON BOILER COMPOUNDS.

THE fundamental idea of the use of any agent of this kind is to counteract the injurious effects of a chemical nature that are found in steam generators of any description and to prevent any interference with the transmission of heat to the water. These effects are oxidization or common rust, electrolysis, called galvanic action or pitting, foaming and priming, and the formation of deposits on the metal called scale.

Steel or iron will oxidize in all natural water, and more so in pure or distilled water, and the same can be said of galvanic action when subjected to a high heat, that is, above 212 degrees.

Water will not "foam" or "prime" except when it is compounded with some substance that will give a "tension" to the water the same as is found in the soap bubble.

As to the formation of scale, we find that nearly all waters carry in solution the following metals: sodium, magnesium, calcium, aluminum, phosphorous, etc., in varying quantities as to the strata of the earth's surface that they come in contact with. These "salts" as they are called, are not met with pure in nature, but are in combination as sodium sulphate, sodium fluoride, sodium chloride, calcium sulphate, calcium corbonate, etc.

We find that the carbonate lime, magnesia, etc., are sometimes deposited by a heat slightly under 212 degrees (as in an open heater), but that in nearly all the cases the deposit does not occur under 258 degrees, which accounts for the deposit formed at or close to the "feed pipe" when the "feed" water entering the boiler meets with the high heat that is only possible in water under a pressure greater than the atmosphere.

Remedies should be of such nature that they will meet with all of these varying conditions both as to quantity of suspended matter, matter in solution and the degree of heat generated.

To counteract oxidization or rust we find that water is the most general solvent known in nature, dissolving even gold, silver, lead, zinc, iron, etc., and to prevent this a substance must be added to the water to "satisfy" it, that it has a greater affinity for than the metal, and in doing this we at the same time prevent electrolysis or galvanic action.

To prevent foaming (or "priming", which is violent "foaming") is to remove all tendency to "soapiness" caused by the oil that gets in boiler in the return water from heater or condenser combining with the soda that nearly all waters contain, thus making actual soap, and that is to combine the soda with a substance for which it has a greater affinity than the oil, thus keeping the water still or quiet.

To prevent the formation of scale is to prevent precipitation, in other words, to keep the various scale forming salts in solution or suspension, and by frequent "blowing off' not allow the water to become "saturated" or so full of these salts that it cannot hold any more, thus depositing on the hotter parts of the generator and causing blisters or bagging from the metal becoming overheated and consequently not strong enough to withstand the pressure.

Nearly everything imaginable has been tried in boilers to reach these results from "buck eye balls," potatoes to all of the minerals and metals, owing to the ignorance and only by judging by a short trial and by what the eye will readily show. Great damage has been the result to not only the boilers but to lives and property by mysterious boiler explosions that can not be explained by any of the well-known causes of low water, cracked sheets, etc.

Heretofore in working out this problem chemists have worked as chemists and engineers have worked as engineers, and of course the problem is still a problem to so many, as it takes time to show results and either side are prone to be satisfied with first results shown quickly; the result has been that so many owners of steam plants have been put to great expense in renewal and repairs that they are discouraged and seek any other means of getting power rather than run the risk of damages and worry.

Nearly all the well water, and the same of surface water, can be said to contain some of the various salts of sodium in solution, as this is one of the most common of metals and is widely distributed in the earth, and being one of the metals that is readily soluble (in fact, cannot be kept pure except in a naptha bath), combining with the oxygen of the air if exposed but a short time. Its action with water is to combine equal parts of oxygen and hydrogen, and as water contains two parts hydrogen to one part oxygen it liberates one part hydrogen, and in a boiler this hydrogen freed from the oxygen will readily combine with the chlorine from common salt (that nearly all waters contain), or sodium chloride, thus freeing more soda to combine and free more hydrogen, and forming with this free hydrogen and chlorine as hydrochloric acid thus giving the necessary acid condition for an electric battery, and the action is intensified by the heat and, as iron is always positive as well as copper, the iron is "pitted," this action going on unnoticed for a time as the "pits" remain filled with the deposit until expansion and contraction of the metal cause them to drop out and they are then found in the lower part of the boiler or mud-drum as small irregular pointed particles and are the black magnetic oxide of iron, and are readily separated from the mud, when dried, with a magnet, and viewed through the magnifying glass

or microscope are readily distinguished from the ordinary oxide of iron, which is always flakey or in sheet form.

Thus you will understand that it is wrong to use any of the "boiler compounds," of which there are so many on the market, that are composed of soda, either carbonate of soda (washing soda), caustic soda (concentrated lye) sulphate of soda (Glaubers salts), chloride of soda (table salt), nitrate of soda, phosphate of soda, and so on, and then combined with a little coloring matter are sold as a something mysterious that comes from Persia or Timbuctoo or some far away country, and is a formula handed down through many generations, thus imposing on the engineers. There are no "boiler compounds" on the market that can not be made by anybody, as there is no way of getting a patent for them, and as a chemist can readily analyze them you will see that the name is all there is to be copyrighted, and as the market price per pound of the various forms of soda is from 90 cents per 100 pounds to $3.50 per 100 pounds you will see how they manage to live when selling at 30 cents per pound dry or 60, 80, 90 cents per gallon in liquid form containing from 80 per cent to 95 per cent water.

M. P. W.

(To be continued.)

PREDETERMINATION OF SAGS IN WIRE SPANS.*

BY R. J. C. WOOD.

IN long span electrical transmission it becomes of great economic importance to accurately predetermine the sag to be given the cables under different temperatures and wind pressures. Every unnecessary foot of sag represents an unnecessary foot of tower or pole, and a consequent waste of money.

The method given below has been found to check extremely closely with experiments made on 1000-foot copper and aluminum and on 700-foot copper spans.

When a cable hangs freely from two supports the forces acting on it are gravity and possibly wind pressure. Due to gravity is the weight of the cable per foot run. Wind pressure is the effective pressure per foot run. The effective pressure being six-tenths of the product of the wind pressure, per square foot of flat surface, and the projected area of cable, per foot run.

W = weight of cable per foot run.
W_0 = weight of ice on cable per foot run.
W_1 = effective wind pressure per foot run.
W_2 = resultant of W, W_0 and W_1.
D = sag in center of span in feet.
S = span in feet.
L = length of cable in span.
p_2 = sag in per cent. of S.
A = cross section of cable in square inches.
T = tension in cable in pounds.
P = stress in cable in pounds per square inch.

* By R. J. C. Wood, Department of the Engineer, Edison Co , Los Angeles.

The fundamental equations based on the assumption that the cable hangs in a parabolic curve are:

$$T = \frac{S^2 W_2}{8D} = \frac{12.5 S W_2}{p_2};\quad L = \frac{S + 8D^2}{3S} = S\left\{1 + \frac{8}{3}\left(\frac{p_2}{100}\right)^2\right\}$$

$$\text{So that } p_2 = \frac{12.5\, S W_2}{PA} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

(1) gives the sag for any given values of wind pressure, size and material of cable and allowable stress.

When the wind ceases to blow the span will fall back to the vertical. The sag will now be less than p_2, since the cable is relieved of the wind pressure and its elasticity causes it to shrink.

L_2 = length of cable acted on by W_2.
L_0 = length of cable all stress removed.
E = modulus of elasticity.

$$\text{Then: } L_0 = \frac{L_2}{1 + \frac{P}{E}}$$

$$\frac{L_0}{S} = \frac{\left(1 + \frac{8}{3}\left(\frac{P_2}{100}\right)^2\right)}{\left(1 + \frac{12.5 S W_2}{p_2 AE}\right)} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The sag p_1 that the length of cable, L_0, will have when hung with span S, there being no ice or wind on it, is most easily found thus:

Take two or three trial values of p_1 in

$$\frac{L_1}{S} = \frac{\left(1 + \frac{8}{3}\left(\frac{p_1}{100}\right)^2\right)}{\left(1 + \frac{12.5 S W}{p_1 AE}\right)} \text{ and}$$

plot p_1 to $\frac{L_1}{S}$ on cross section paper. Find by interpolation the value of p_1 making $\frac{L_1}{S} = \frac{L_0}{S}$.

To sum up: The cable, if strung with the sag p_1, there being no ice or wind, will blow out, under the action of both, and stretch till the sag = p_2. There will then be equilibrium and the stress in cable will be P pounds per square inch.

Consider now how temperature changes will affect p_1, since in the above analysis the temperature was supposed constant and equal to the lowest at which maximum wind pressure may occur.

$$L = S\left\{\frac{\left(1 + \frac{8}{3}\left(\frac{p_1}{100}\right)^2\right)}{\left(1 + \frac{12.5 S W}{p_1 AE}\right)}\right\} \text{ at temperature } t_1 \ldots\ldots\ldots (4)$$

$$L_2 = S\left\{\frac{\left(1 + \frac{8}{3}\left(\frac{p_2}{100}\right)^2\right)}{\left(1 + \frac{12.5 S W}{p_1 AE}\right)}\right\} \text{ at temperature } t_2 \ldots\ldots\ldots (5)$$

These are the lengths of cable, with stress removed, at temperatures t_1 t_2.

a = coefficient of expansion, per degree Fahrenheit.

$t^0 = t_2 - t_1$.

Then $L_2 = L_1 (1 + at^0)$, exactly, if t_1 is the zero temperature for the coefficient a, and nearly enough in all practical cases. Also L_1 is very nearly $= S$.

With very close approximation therefore, $Sat^0 = L_2 - L_1$.

Substituting from (4) and (5) and simplifying

$$t^0 = \frac{1}{a}\left\{\frac{8\,(p_2^2 - p_1^2)}{30{,}000} + 12.5\,\frac{WS}{AE}\left(\frac{1}{p_1} - \frac{1}{p_2}\right) + \frac{WS}{300AE}\left(\frac{p_2^2}{p_1} - \frac{p_1^2}{p_2}\right)\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

The last term is negligible so that

$$t^0 = \frac{1}{a}\left\{\frac{8\,(p_2^2 - p_1^2)}{30{,}000} + 12.5\,\frac{WS}{AE}\left(\frac{1}{p_1} - \frac{1}{p_2}\right)\right\} \quad \ldots\ldots (7)$$

a, $\frac{W}{A}$, E are constants for any given material as in the the table below:

	a	$\frac{W}{A}$	E
Stranded M. H. D. copper ...	0.0000096	3.85	16,500,000
Stranded aluminum	0.0000128	1.17	8,500,000

Substituting these valnes in (7).

For copper $t^0 = 27.75\,(p_2^2 - p_1^2) + 0.303\,S\left(\frac{1}{p_1} - \frac{1}{p_2}\right)$ ..... (8)

For aluminnm $t^0 = 20.8\,(p_2^2 - p_1^2) + 0.134\,S\left(\frac{1}{p_1} - \frac{1}{p_2}\right)$ (9)

Where as already stated p_1 = sag at temperature t_1.

p_2 = " " " $t_1 + t^0$.

The following example will illustrate: Required the sag temperature curve for a 400-foot span of No. 0000 seven-strand copper. Stress in cable not to exceed 22,000 pounds per square inch when cable has a one-half inch coating of ice, temperature is $0^\circ F$ and wind pressure is thirty pounds per square foot.

$W = 0.64$.

$W_0 = 0.65$.

$W_1 = \frac{1.53}{12} \times 0.6 \times 30 = 2.3$ diameter of ice-coated cable $= 1.53''$.

$W_2 = 2.64$.

$S = 400$.

$A = 0.166$.

$P = 22000$.

From (1) $p_2 = \dfrac{12.5 \times 400 \times 2.64}{22000 \times 0.166} = 3.6$ per cent.

From (2) $\dfrac{L_0}{S} = \dfrac{1 + \frac{8}{3}\left(\frac{3.6}{100}\right)^2}{1 + \frac{12.5 \times 400 \times 2.64}{3.6 \times 0.166 \times 16{,}500{,}000}} = 1.002113$

p_1 will be somewhat less than p_2, so taking trial values of p_1 in (3).

$p_1 = 3.2$ gives $\frac{L_1}{S} = 1.002365$.

$p_1 = 3.0$ gives $\frac{L_1}{S} = 1.002009$.

Plotting and interpolating it is found that

for $p_1 = 3.07$, $\frac{L_1}{S} = 1.002113 = \frac{L_0}{S}$.

It is thus determined that the cable should be strung with a sag of 3.07 per cent., or 12 feet at $0^\circ F$.

Now in (8), $p_1 = 3.07$, giving different values to p_2, for

$p_2 = 3.07$	$t^0 = 0$
$= 3.2$	$= 24.6$
$= 3.4$	$= 62.9$
$= 3.6$	$= 104.1$

These are sufficient points to determine the curve which is very nearly a straight line.

It is the required sag-temperature curve, showing the sag to be given at any temperature to insure the cable against greater than the stipulated stress.

THE NIAGARA FALLS CONCRETE DAM.

A unique piece of engineering was recently accomplished at Niagara Falls, Ont. The Park and River Railroad Company, finding that the amount of water passing through their wheels was barely sufficient, resolved to raise the head by means of a dam. Seeing that the in-take of the company is situated about 600 feet from the crest of the horseshoe fall, and as the rapids at this part are very swift, it will be easily understood that the undertaking presented no ordinary difficulties.

After consideration it was resolved to build a concrete dam on shore and tip it into the river. A timber base was erected of sufficient height to allow the in-shore end of the dam, when tipped, to be about fifteen feet from the shore, and on top of this was erected a concrete pillar fifty feet high and six feet one inch square. In order that the dam might conform to the bed of the river, there were inserted every eight feet or so wooden wedges extending half-way through the column, and to insure the pieces remaining together a heavy chain was embedded in the center, due allowances be.ng made at the joints.

On November 9th, after a month's drying in the air, at 3.08 p. m., hydraulic jacks were inserted below the timber base, and shortly after, the huge mass, weighing about 300 tons, commenced to tip, and about 4:35 p. m., fell into its place with a grand splash.

Immediately after soundings were taken, and it was found the water in the in-take had been raised ten and one-half inches, as was anticipated. Great credit is due Isham Randolph, C. E., Chicago, who planned and carried through this novel piece of engineering.

AN ELECTRICALLY EQUIPPED VESSEL.

The Amerika, the fine steamship built in Great Britain and lately added to the Hamburg-American line, comes nearer being electrically equipped throughout than any other steamer. Wherever possible small motors have been fitted to drive the machinery throughout the vessel, and in addition there are an electric elevator, electric call systems, a telephone exchange, with connection in all state-rooms, electrically operated bulkhead doors, a submarine signalling system, wireless telegraph apparatus, electric light, fans and baths. Electric ventilation is installed throughout, and such minor details as boot-cleaning machines, barbers' brush machines, knife-cleaning machines, doughmixers, etc., are all run by electricity.

THE CENTRIFUGAL PUMP AND ITS APPLICATION.

BY HARRY Y. HADEN.

THE centrifugal pump is not of recent origin. Mention is made in the middle of the eighteenth century by Euler, the great mathematician, of a pump which was operated by centrifugal force. Again in 1830, such a pump was in use in the U. S. navy yard at New York, the patent of Mr. McCarthy.

The first pump, however, to show any real efficiency, was the Appold pump, exhibited at the London exhibition of 1851. It was stated to have an efficiency of "more than double the efficiency of any other pump of its kind." From that time to the present and especially during the last ten to fifteen years, considerable money and time have been spent to bring it up to its present standard of efficiency.

In its essentials, the centrifugal pump is very simple, merely consisting of a revolving fan having two or more blades, either straight or curved, attached to a revolving spindle and enclosed in a case so arranged that the suction water enters in at the side and the delivery leaves tangent to the path of the revolving blades. The pump may be designed so that the water enters in at the one side, the design of the blades such as counteract the resultant end thrust, or the pump may be of the double suction type, *i. e.:* the water entering from both sides of the pump wheel, thereby leaving the same in balance, and avoiding end thrusts.

Figure 1 shows a general diagram of a double suction centrifugal pump, giving the pump case, the pump wheel or "impeller," and the spindle.

A A is the suction chamber and *B B* the delivery. In the above it will be seen that the efficiency of such a pump, outside of its properly designed blades, depends considerably in the absence of any connection, except through the "impeller," between the delivery and suction chambers. In the above example this is arranged by having a close fit between the pump wheel and the pump case at the point *C C*, and in order that repairs may be made at this point cheaply, an interchangeable ring is screwed on the "impeller," which can easily be removed if serious cutting has taken place. In other words, this part of a centrifugal pump is very similar to the piston and piston rings of the reciprocating brother.

The actual construction of such a pump is shown in Figure 2, where the ring is plainly seen.

Naturally the most important factor in the pump is the design of the "impeller" blades, and in this connection much has been done of late in the way of designs and curves that produce results on par with the reciprocating pump of today.

Strictly speaking, the centrifugal pump is a constant speed machine, although actual experiment has gone to show that in some cases excellent efficiencies are maintained at varying speeds, provided they are not of too great a range.

Figure 3 shows three diagrams representing three different designs of blades which, generally speaking, will give the three corresponding "characteristics" shown in

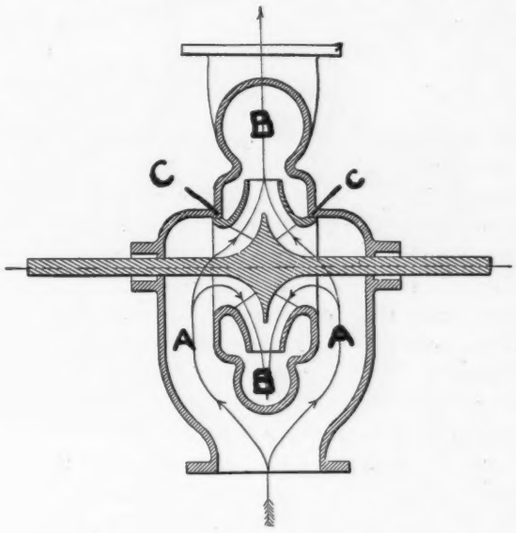


FIGURE 1.

Figure 4. By characteristic is meant the performance and relationship between the quantity and the "head."

The following are three examples where all these forms would come into use:

Firstly, supposing a pump were emptying a basin so that the suction head were constantly increasing, a characteristic similar to the one shown in I. of Figure 4, will allow of the pump whilst running under governor at constant speed to maintain practically a constant efficiency

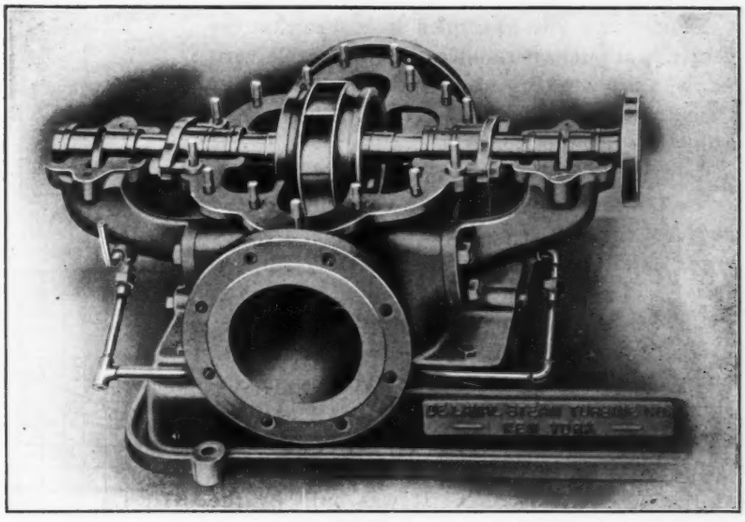


FIGURE 2.

while the head should vary 30 or 40 per cent. Another feature of this same characteristic is that were the quantity to suddenly increase, owing to an accidental reduction of the head, it would not result in a serious overload

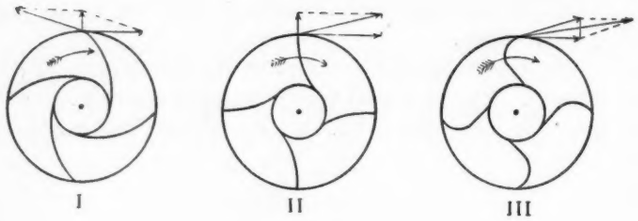


FIGURE 3.

for the motor, for the horsepower would not increase however much the quantity did.

Diagram II. in Figure 3, and curves II. in Figure 4, show the design in the case of a pump required to deliver a variable quantity of water against a constant head whilst running at a constant speed. Examples of pumps running under these conditions would be when supplying water for an elevator system or for feeding a battery of boilers, where it is obvious that a steady pressure must be held regardless of qantity.

In this last pump it is seen that the "characteristic" can be made to drop down soon after the maximum efficiency is passed, thereby again preventing the overloading of the unit, by keeping the water horsepower from rising. The dotted line shows how the quantity would continue to increase were this provision not made.

Numbers III. in Figures 3 and 4, show the design of blades and characteristic applicable in a case involving a water system in which the friction of the piping is a large part of the whole head at full delivery, and then when the system reduces its demand for water and thereby largely reduces the friction head, the pump would automatically adjust itself to the reduced head without change of speed.

From these few examples it is seen that the centrifugal pump is capable of considerable variation in the working conditions and is still able to maintain a reasonable efficiency whilst operating at a constant speed.

Centrifugal pumps are similar to electric generators in respect that two of the same kind may be either coupled in series or in parallel, thereby either doubling the lift or the quantity respectively. They are built in series up to as much as five stages and give highly successful results.

A good example of a five-stage centrifugal pump is shown in Figure 5, which is a pump designed to give 10,000 gallons of water per minute against a head of 430 feet. This pump was tested up to 577 feet, and is held to be the biggest of its kind in existence. It was built by the Byron Jackson Machine Works, of San Francisco, and is in service at Grants Pass, Or.

Figure 6 shows a 3,000,000 gallon pump direct connected to a 150 horsepower De Laval Steam Turbine, made by the De Laval Company, in Trenton, N. J. The discharge head on this pump is 200 feet, and it is used in conjunction with elevator and fire service in an eastern city. The speed of the impellers in this pump is 1200 revolutions per minute.

Many mistaken figures are flying about with regard to the efficiencies developed by centrifugal pumps, and some pump people in a burst of enthusiasm talk in gentle tones of 85 per cent. and over, and scorn any lower figure. It is a pity such statements are made, for it tends to prejudice the laymen in believing the actual figure. Although 80 per cent. and 85 per cent. may be a common result a few years from now, or even in a few months, the lower figure today probably represents the top notch in the efficiency.

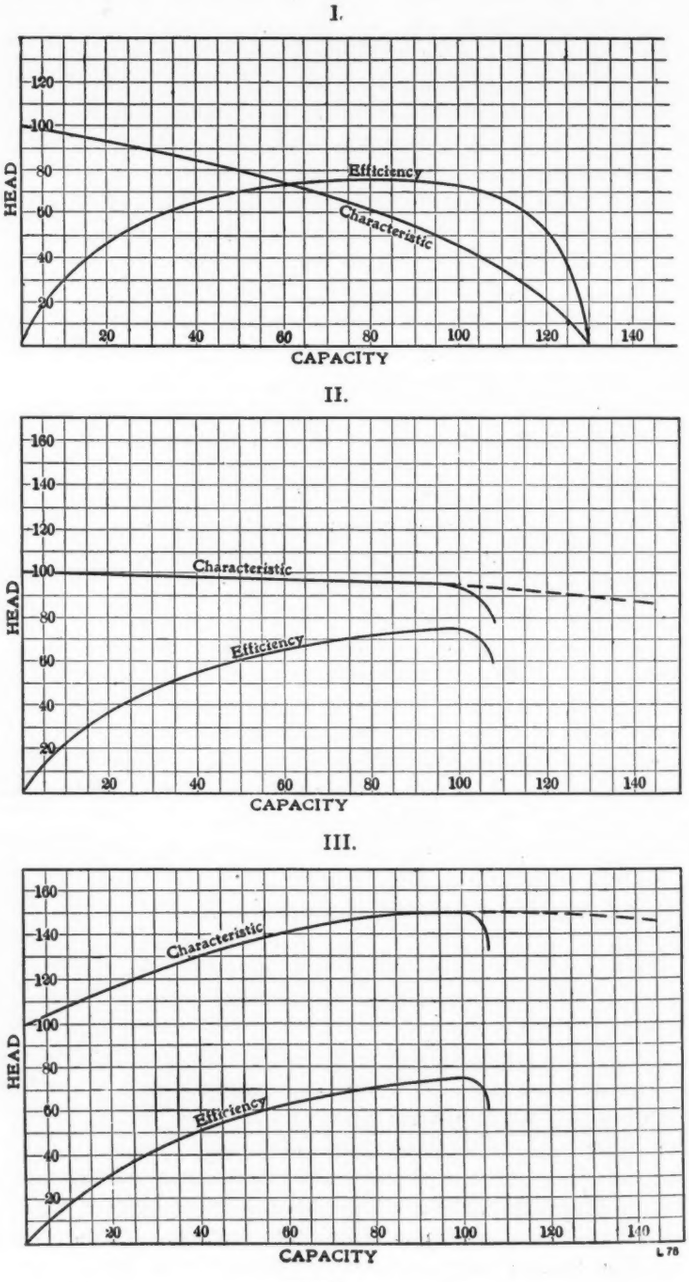


FIGURE 4.

Here it might be stated that what is meant by efficiency is $\frac{\text{Water horse power.}}{\text{Brake horse power.}}$

Efficiencies ranging from 70 per cent. to 75 and 76 per cent. have been the most common in the observance of the author, although there is no doubt that higher efficiencies have been obtained in reliable tests. Naturally the efficiency depends a good deal on the size of the pump, and these figures given above pertain more to units of 5,000,000 gallons capacity and under. With a large pump of favorable capacity it is quite possible a reliable firm might be in a position to guarantee 80 per cent. or over.

The efficiencies mentioned before are obtainable in all varying lifts, from 30 feet to 500 and over.

Below is given an exhaustive test on an electro-motor pump of 1200 gallons a minute capacity and forty-five feet head.

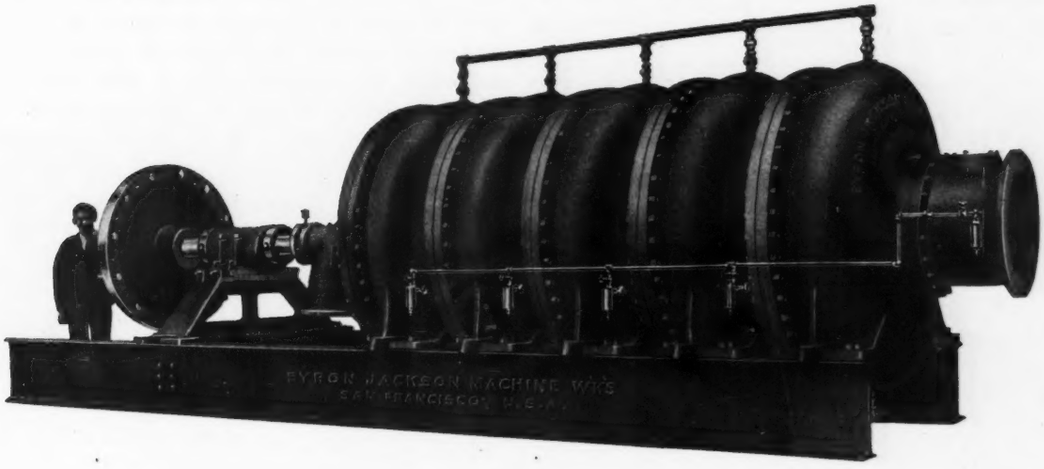


FIGURE 5.

The test was conducted by Dean William Kent, of Syracuse University, and by Professor J. E. Denton, of Stevens Institute. Three methods were used to check the water quantities; the pitot tube, the weir method

TEST OF ELECTRO-MOTOR CENTRIFUGAL PUMP

No. of Test	Time of the Test Year, 1904 Day, Apr. 7 Hour	Volts	Amperes	E. H. P.	Brake Horsepower	Revolutions per Minute	Cubic Feet of Water per Second		Ratio $Q \div Q^1$	Water Horsepower	Vacuum in the Suction Pipe, Inch Mercury	Depth of Suction, Feet Water Column.	Water Press in the Discharge Pipe, Lbs. Square Inch	Height of Water in the Discharge Pipe, Feet	Total Head, Feet	Height of Weir, Feet	Press in the Pitot Tube, Feed Water	Water Quantity Gallons per Minute, By Weir	Effi ciency of Pump
							Weir Q	Pitot Q^1											
2	3.40–4.04	242.3	54.8	17.80	14.94	1,996	3.126	3.217	.972	10.67	9.62	10.09	16.96	19.22	30.12	.631	10.29	1,403	.714
3	4.10–4.18	242	59	19.14	16.22	1,996	2.885	2.977	.970	11.80	8.02	9.1	11.7	27	36.1	.597	8.29	1,295	.728
4	4.25–4 39	241.8	62.9	20.39	17.41	2,000	2.525	2.603	.971	13.06	6.87	7.78	16.4	37.88	45.66	.5435	6.33	1,133	.750
5	4.45–4.53	241.4	64	20.71	17.71	2,003	2.197	2.251	.976	13.12	6	6.8	19.8	45.9	52.7	.494	4.75	986	.742
6	5.05–5.15	242	62	20.11	17.14	2,003	1.760	1.803	.976	11.71	5	5.66	23	53.1	58.76	.424	3.04	790	.683
7	5.20–5.26	242.5	55.2	17.94	15.07	2,006	3.158	3.290	.961	10.25	9.38	10.6	.....	17.92	28.52	.6375	10.125	1,417	.680
8	5.35–5.43	242	62.4	20.24	17.27	2,005	2.826	2.910	.972	12.18	20	22.65	13.59	15.4	38.05	.588	7.92	1,268	.706
9	5.52–6.00	240.8	66	21.30	18.28	2.005	2.504	2.602	.964	13.40	19.25	21.8	22.45	25.45	47.25	.546	6.33	1,124	.733
10	6.05–6.12	239.7	66.3	21.30	18.28	1,997	2.179	2.244	.972	13.15	19.5	22.1	12.5	31.18	53.28	.491	4.71	978	.720
11	6.20–6 28	240.9	63.2	20.41	17.43	2,007	1.735	1.791	.969	11.42	19.88	22.3	15.5	35.8	58.10	.420	3.00	779	.655
12	6.35 Shut off	248	34	11.30	8.74	2,040	.....	.....	.....	.....	.....	.....	. ..	.....	68.39	.....	.....	.....	....

The pump wheel was designed for 2000 revolutions and was 8.55 inches in diameter.
Tests 1 to 7 had the suction valve wide open.
In tests 7 to 11, the suction valve was throttled.
In test 7, the delivery valve was wide open.

and the time taken to fill a tank of known capacity, and they all checked up within 1 per cent., thereby making it a very reliable result.

The compactness of the centrifugal pump allows of an easy installment, and the absence of vibration a less costly foundation than a reciprocating pump would demand. Its automatic lubrication is also a point in its favor.

One point to be remembered about a centrifugal pump is its inability to start its own suction. Therefore arrangements have to be made in the installation to have the pump case full of water before starting up. This

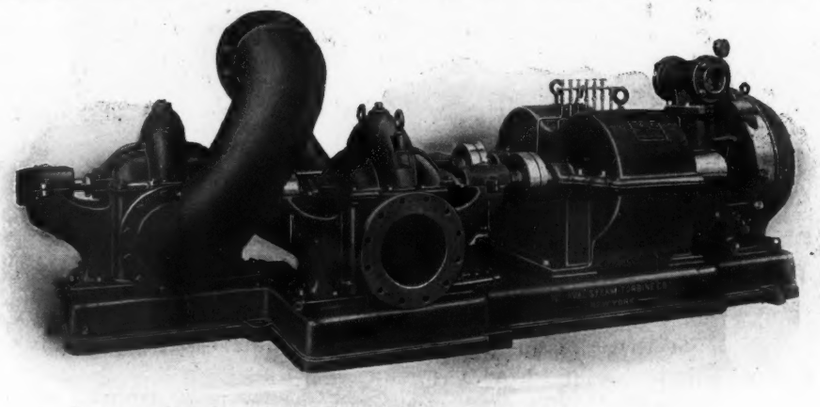


FIGURE 6.

may be done in several ways: By having a by-pass from the source of delivery to the pump case. By using a foot valve and thereby keeping the water back in the pump and delivery pipes, and, if in the case of a steam unit, the use of an injector. The last method is simple and effective.

In conclusion the writer believes that the field for the centrifugal pump is surely going to be an immense one. The simpler a machine or engine is in its essentials, the greater chance it has to find favor, provided the efficiency is justifiable.

THE COMING OF THE TURBINE.

Professor Silvanus P. Thompson, F. R. S., recently delivered the first of three Howard lectures on High-speed Electric Machinery, with special reference to "Steam Turbine Machines," before the Society of Arts. "When electric lighting first began to assume a commercial aspect," said the professor, "no engineer dreamed of driving a dynamo by any other method than by applying a pulley to its shaft and belting this pulley to a pulley on the shaft of a steam engine either directly or through some countershaft. The steam engines of that day were almost without exception slow-speed engines, while the early dynamos required high speeds, and there was no choice but to drive by gear or belting. The large stations which grow up by hundreds in the United States were marvels of engineering at cross purposes, the engine builders having their slow-speed engines and the dynamo builders their standard high-speed dynamos. It was clear that devolopment might come in either of two directions: the electric generator might be designed to suit the low-speed engine, or the engine might be developed to suit the high-speed generator. Progress took the former of these courses on the Continent where the large slow-speed type of generator was evolved. In the meantime, the opposite kind of development was going on in England. Yet all the while the steam turbine was being evolved, and in spite of the improvement which had taken place in the high-speed reciprocating engine, it soon began to find a formidable rival in the steam turbine.

"One broad fact stood out above all these considerations, the advantage gained by the adoption of a high peripheral speed. The last few yaers had witnessed a very important development in the processes of designing by the discovery and use of certain rational formulæ which, while based on first principles and therefore true for all classes of machines for all different makers, contained certain co-efficients, the value of which was determined by experience. The outstanding formulæ gave a direct means of starting with proper dimensions, and if they did not form an immediate solution to the question of the cheapest machine, they furnished the designer with a number of *prima facie* designs, each of which would fulfill the specifications, and from which he could select the one which under the conditions would be the cheapest to construct. —*Engineering Times*, London, Jan. 25.

AN AUTOMOBILE POWER PLANT.

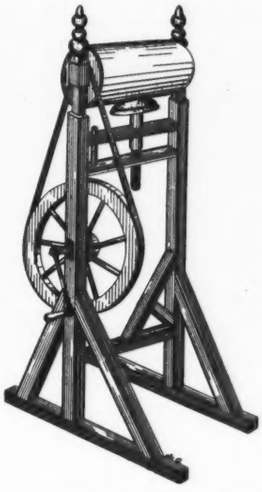
A concern in Paris is making an attachment for automobiles for transmitting power to run an electric light generator, pump water and do other usefulwork. There is little occasion for this in city houses, but at summer homes, at lakes and for other isolated residences the power may be found extremely convenient. Lighting may be done direct from the generator to the lamps, but in this case there would be no light if the auto were taken out for an evening ride. By using storage batteries which can be charged night or day at times when the auto is not wanted, current can be stored to supply the lights at all hours. The *Electrical Review*, London, says: "The arrangement will be found especially useful in small country houses, distant from a gas or electricity supply, and where not utilized for electric lighting purposes, the dynamo may be replaced by a pump to insure a good water supply, or the motor may be connected up to a sewing machine or other domestic machine."

LIGHTNING AND THE ELECTRICITY OF THE AIR.

BY ALEXANDER G. McADIE.

FRANKLIN'S KITE EXPERIMENT.

ONE hundred and sixty years ago a ragged colonial regiment drew up before the home of its philosopher-colonel and fired an ill timed salute in his honor. A fragile electrical instrument was shaken from a shelf and shattered. Franklin doubtless appreciated the salute and regretted the accident. In the course of his long life he received other salutes, as when the French Academy rose at his entrance, and he constructed and worked with other electrometers; but for us that first experience will always possess a peculiar interest. The kite and the electrometer betray the intention of the colonial scientist to explore the free air, and, reaching out from earth, study air electrification *in situ*. He made the beginning by identifying the lightning flash with the electricity developed by the frictional machine of that time. A hundred patient philosophers have carried on the work, improving methods and apparatus, until today we stand upon the threshold of a great electrical survey of the atmosphere. It is no idle prophecy to say that the twentieth century will witness wonderful achievements in measuring the potential of the lightning flash, in demonstrating the nature of the aurora, and in utilizing the electrical energy of the cloud. The improved kite and air-runner will be the agency through which these results will be accomplished.



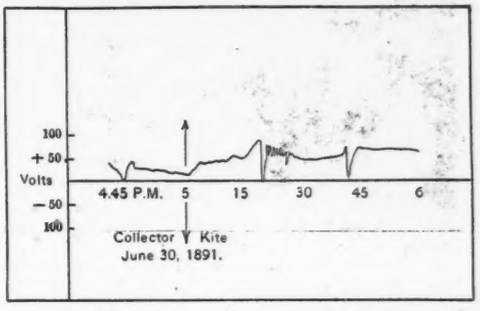
FRANKLIN'S ELECTRICAL MACHINE.

The famous kite experiment is described by Franklin in a letter dated October 19, 1752:

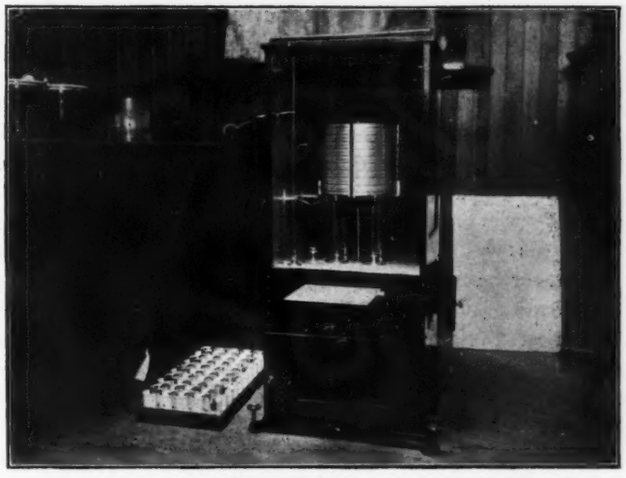
"Make a small cross of light sticks of cedar, the arms so long as to reach to the four corners of a large, thin silk handkerchief when extended. Tie the corners of the handkerchief to the extremities of the cross, so you have the body of a kite which, being properly accommodated with a tail, loop, and string, will rise in the air like those made of paper, but being made of silk is better fitted to bear the wet and wind of a thunder gust without tearing. To the top of the upright stick of the cross is to be fixed a very sharp-pointed wire rising a foot or more above the wood. To the end of the twine next the hand is to be tied a silk ribbon, and where the silk and twine join a key may be fastened. This kite is to be raised when a thunder gust appears to be coming on, and the person who holds the string must stand within a door or window, or under some cover, so that the silk ribbon may not be wet; and care must be taken that the twine does not touch the frame of the door or window. As soon as the thunder clouds come over the kite, the pointed wire will draw the electric fire from them, and the kite, with all the twine, will be electrified, and stand out every way and be attracted by an approaching finger. And when the rain has wet the kite and twine you will find the electric fire stream out plentifully from the key on the approach of your knuckle."

Now, how would we perform this experiment today, and with what results? Having flown big kites during thunderstorms, it may perhaps be best to describe step by step two of these experiments, and then speak of what we know can be done, but as yet has not been done.

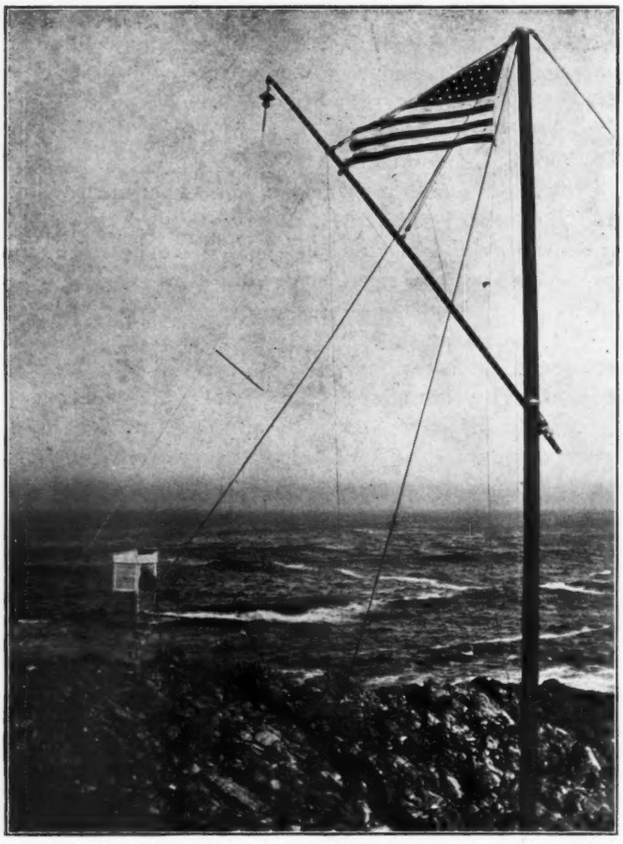
Our first repetition of Franklin's kite experiment was at Blue Hill Observatory, some ten miles southwest of Boston, 133 years after its first trial. There were two large kites silk-covered and tin-foiled on the front face. These kites were of the ordinary hexagonal shape, for in 1885 Malay and Hargrave kites were all unknown to us. Fifteen hundred feet of strong hemp fishline were wrapped loosely with uncovered copper wire of the smallest diameter suitable, and this was brought into a window on the east side of the observatory, through rubber tubing and blocks of paraffin. Pieces of thoroughly clean plate glass were also used. Materials capable of giving high insulation were not so easily had then as now. We knew very little about mica; and quartz fibers and Mascart insulators could not be obtained in the United States. Our electrometer, however, was a great improvement upon any previous type, and far removed from the simple pith-ball device used by Franklin. Knowing that an electrified body free to move between two other electrified bodies will always



ELECTRICAL POTENTIAL OF THE AIR. SMALL COLLECTOR ABOUT 15 FEET FROM GROUND; KITE ABOUT 500 FEET FROM GROUND



MULTIPLE QUADRANT ELECTROMETER USED AT BLUE HILL OBSERVATORY

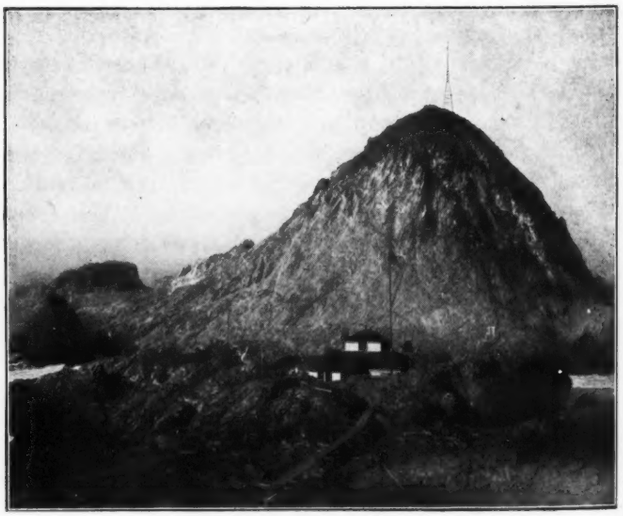


WIRELESS STATION, SOUTHEAST FARALLON, WHICH RESPONDS TO THUNDERSTORMS IN SIERRA, 175 MILES DISTANT

move from the higher to the lower potential, Lord Kelvin devised an instrument consisting of four metallic sections, symmetrically grouped around a common center and inclosing a flat free-swinging piece of aluminum called a needle. The end of the kite wire is connected with the needle and the sections or quadrants are alternately connected and then electrified, one set with a high positive potential, say 500 volts, and the other with a corresponding negative value, say 500 volts, lower than the ground.

Perhaps the most noteworthy result of these earlier experiments was the discovery (for such we think it was) that showery or thunderstorm weather was not the only condition giving marked electrical effects. The electrometer needle would be violently deflected and large sparks obtained at other times. Day after day as we flew the kite we found this high electrification of the air, and we had no trouble in getting sparks even when the sky was cloudless. One other discovery was made, and this would have delighted Franklin more than the other, for he was always most pleased when a practical application was in sight. Seated within the instrument room of the observatory, with his back to the open window through which came the kite wire carefully insulated, and the kite high in air, the observer closely watching the index of the electrometer could tell positively, and as quickly as one outside watching the kite, whether it rose or fell. When the kite rose, up went the voltage, and vice versa. In other words, the electric potential of the air increased with elevation. It must be confessed that the kites made today would have behaved better and flown with more steadiness than the one we used. It may have been the varying wind, or more likely wrong proportions in the kite and tail; but our old hexagonal kite would dive even when high in air. Once we kept the kite aloft from the forenoon until late at night, but that was something unusual.

Passing now over six years in which we had been busy measuring the electrification of the air under all conditions, and discovering, for example, that a snowstorm was almost identical with a thunderstorm in its tremendous electrical changes, we come to the year 1891, when we again flew kites for the purpose of electrically exploring the air. Our experiments at the top of the Washington Monument in 1885 and 1886 (especially those during severe thunderstorms, when we obtained potentials as high as three and four thousand volts just before the lightning), had given us an insight into the strains and stresses in the air, and taught us what to expect at such times. There was still little improvement in the kite, but much better electrical apparatus was at hand. It may seem ridiculous, but we hauled nearly a wagon load of electrical apparatus to the summit of the hill, and found occasion to use all of it. Our insulators were delicate glass vessels curiously shaped, containing sulphuric acid, and able to hold with little leakage the highest known potentials. Besides these fine Mascart insulators, we had hundreds of distilled-water batteries and two electrometers, one a Mascart quadrant, the other a large multiple quadrant. The chief aim that year was to secure by mechanical means (discarding the photographic and eye methods) a continuous record of the potential. When we can study the potential at any moment and still have a record of it, the relation of the electricity of the air to the pressure, temperature, and moisture will be more easily investigated. Among our records that year there is one date, June 30, 1891, when a direct comparison of the electrification of the air fifteen or twenty feet from the



U. S. WEATHER BUREAU ON FARALLON ISLAND

ground and at a height of about 500 feet is shown. In one, the potential was obtained by a water-dropper collector from a second-story window in the observatory, and in the other was obtained by means of the kite. It will be seen how much higher the kite values are, although the kite was a much slower accumulator of electricity. In the next year, 1892, the kite was flown several times during thunderstorms, but generally during afternoon storms; and in the lull preceding the wind rush the kite would fall. It was not until August 9, that we succeeded in going through a storm with the kite still flying. About 11 a. m. the kite was sent aloft, and it remained aloft until after 10 p. m. From the observatory one can see to the west fifty or more miles, and a thunderstorm came into view just about sunset. The kite was flying steadily, and whenever a finger was held near the kite wire there was a perfect fusilade of sparks. As the darkness increased, the polished metallic and glass surfaces in the large electrometer reflected the sparks, now strong enough to jump across the air gaps, and the incesssant sizzling threatened to burn out the instrument. The vividness of the lightning in the west also made it plain that the storm was one of great violence, and as the observatory itself would be jeopardized, one of the four men present proposed to cut the wired string and let the kite go. But even that was easier said than done, for to touch the string was to receive a severe shock. It was necessary, however, to get out of the scrape, and one of the party took the kite string and broke the connection with the electrometer and insulators. While he was in the act of doing this, the others, who by this time were outside the building, saw a flash of lightning to the west of the hill. The observer who was undoing the kite wire did not see this flash. He saw a brilliant flare up in the electrometer, and at the same instant felt a severe blow across both arms. Notwithstanding, he loosened the wire, and dropping an end without, it took but a few moments to make it fast on the hillside some distance away from the observatory. There it remained for the rest of the night. A 105-volt incandescent lamp was placed between the end of the kite wire and a wire running to the ground. There was some light, but no incandescence of the filament. It was more in the nature of a creeping of the charge over the outer glass surface of the lamp. Stinging sparks were felt whenever the kite wire was touched. The storm gradually passed over, the lightning being vivid and frequent in the west and north, and, as we learned next day, doing considerable damage. The nearest flash to the hill, however, as well as we could determine by the interval between thunder and flash, was 4500 feet away, so that the discharge which the observer felt while loosening the wire must have been a sympathetic one. We obtained a photograph of the prime discharge, and very curiously this shows a remarkable change of direction.

SOUTHEAST FARALLON, TWENTY-SIX MILES SOUTHEAST OF SAN FRANCISCO

This year, in some interesting experiments made on the roof of the Mills Building at San Francisco, it was noticed that the roof, which has a covering of bitumen, was a good insulator. Ordinarily one may touch the reel on which the kite wire is wound without being shocked, but if a wire be connected with the ventilating pipes running to the ground there are small sparks. Introducing a condenser in the circuit, the intensity of the spark is increased. It only remains to construct an appropriate coil of the kite wire and place within it an independent coil. In the outer coil a quick circuit breaker may be placed, and theoretically, at least, we shall transform down the high potential and low amperage charge of the air to a current of less potential and greater amperage. This can be put to work and the long delayed realization of Franklin's plan of harnessing the electricity of the air will be consummated.

ELECTRIFICATION OF THE ATMOSPHERE.

Franklin, in addition to many other experiments upon the electrification of the air, erected upon his house an iron rod with two bells. When the rod was electrified the bells were rung. By charging Leyden jars and testing the sign of the electrification, he came to the conclusion that "the clouds of a thunder gust are most commonly in a negative state of electricity."

A detailed history of most of Franklin's colaborers mao be found in the eccounts gived by Exner,* Hoppe,† Mendenhall,‡ Elster and Gietel.§ The author‖ has also given a brief summary.

The following table will give at a glance the work of the chief investigators from the time of Franklin to the end of the eighteenth century. Passing Peter Collinson,

* Ueber die Ursache und die Gesetze der atmospharischen Electricita." Von Prof. Franz Exner. Repertiorum der Physik. Band XXII. Heft 7.

† Ueber Atmospharischen und Gewitter Electricitat. Meteor. Zeits. 1, 2, 3 and 4, 1885.

‡ Memoir of National Academy of Sciences.

§ (*a*) Report of Chicago Meteorological Congress Part II. August, 1893. (*b*) Zusammenstellung der Ergebnisse neuerer der Arbeiten uber atmospharische Electricitat. Von J. Elster und H. Geitel. Wissen. Beilage zum Jahresbericht des Herzoglichen Gymnasiums zu Wolfenbuttel, 1897.

‖ (*a*) Observations of Atmospheric Electricity. American Meteorological Journal. 1887. (*b*) Terrestrial Magnetism. December, 1897.

of London, who introduced to the notice of the Royal Society the experimehts of Franklin and the three less known workers—J. H. Winkler, who wrote in 1746 on the electrical origin of the weather lights; Maffei, 1747; and Barabet, 1750—we have:

DATE	NAME	EXPERIMENTS	REFERENCES
1751	Franklin	Effects of lightning	Phil. Trans., xlvii, p. 289
1751	Mazeas	Kite experiments	Phil Trans., 1751, 1753
1752	Nollet	Theory of electricity	Recher. sur la causes, 1749–1754
1752	Watson	Electricity of clouds	Phil. Trans., 1751, 1752
1752	De Lor de Buffon	Iron pole 99 ft. high, mounted on a cake of resin 2 feet square, 3 inches high, Estrapade, May 18, 1752	Letter of Abbe Mazeas, dated St. Germain, May 20, 1752
1752	D'Alibard	Sparks from thunder clouds, 40 foot pole in garden at Marly; also wooden pole 30 feet high, at Hotel de Noailles	Mem. l'Acad. r. des. Sci., May, 1762
1752	Le Monnier	Observations of air charge	Mem. de Paris, 1752
1752	De Romas	Observations of air charge; kite experiments	Mem. Sav. Etrange II, 1752
1752	Mylius Ch	Observations of air charge	8 vo., Berlin, 1752
1752	Kinnersley	Observations of air charge	Franklin's Letters, Phil. Trans., 1763. 1773
1752	Ludolf and Mylius	Observations of air charge	Letter to Watson
1753	Richman	Electrical gnomon	Phil Trans.. 1753
1753	Canton	Electricity of clouds	Phil Trans , 1753
1753	Beccaria, C. B.	Systematic observations with an electroscope	Lett. del Elet. Bologna, 1758
1754	Lining	Kite experiments	Letter to Chas Pinckney
1753	Wilson	Experiments	Phil. Trans., 1753, p. 347
1755	Le Roy	Experiments	Mem. de Paris, 1755
1756	Van Musschenbroek	Kite experiments	Intro. ad Phil. Nat., 1762
1759	Hartmann	Origin of electricity	
1769	Cotte	Memoirs on meteorology	Journ. Phys., xxiii, 1783
1772	Roynane	Fog observations	Phil. Trans., 1772
1772	Henley	Quadrant electrometer	Phil. Trans., 1772
1775	Cavallo	Fogs, snow, clouds and rain; kite experiments	Treatise on Elec., 1777
1784	De Saussure	Observations	Voyage dans les Alpes
1786–7	Mann	Daily observations with an electrical machine, timing the revolutions to produce a given spark with a record of the weather	
1788	Volta	New electroscope	Lettere Sulla Meteor, 1783.
1788	Crosse	Experiments with collectors	Gelb. Ann. Bd., 41
1791	Reed	Insulation and conductors	Phil. Trans., 1791
1792	Von Heller	Observations	Green's Jour. d. Phys., 2 Bd., 4
1792	Schubler	Observations with weather rod	J. de Phys., lxxxiii

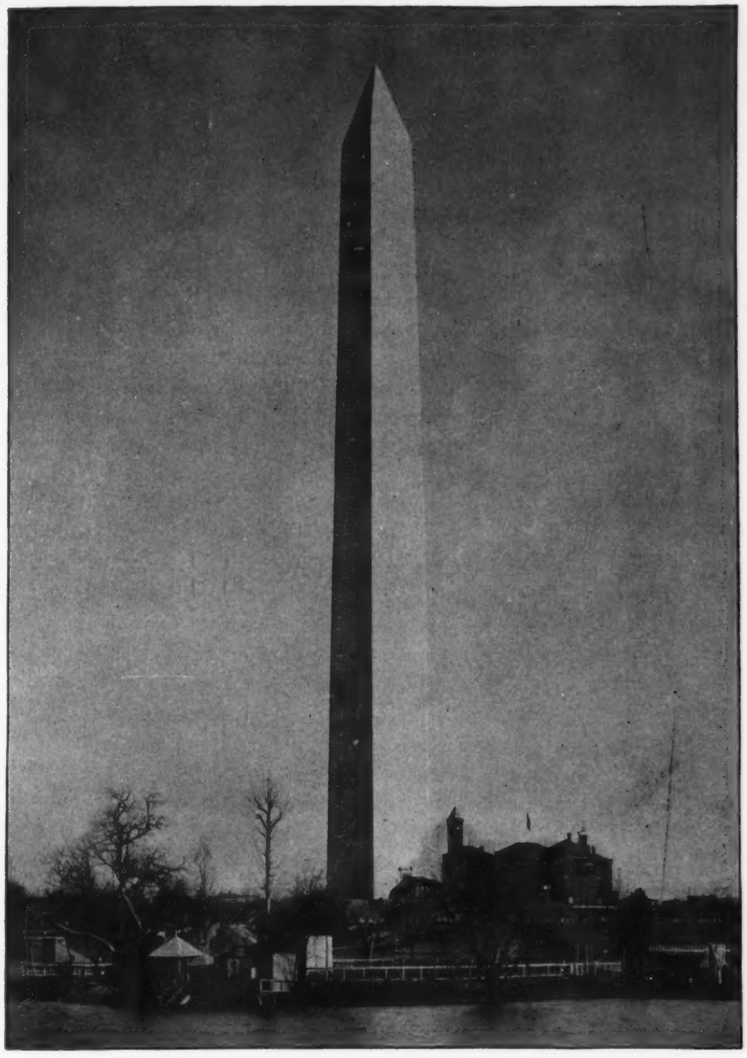
At the beginning of the nineteenth century, Schubler, at Tubingen, systematically observed for twenty years and worked out a curve of diurnal variation. Double maxima and minima were determined; the first maximum about 8 a. m., and the second about 8 p. m. The minima occurred before sunrise and about sunset. Corelating the values with weather conditions, Schubler found in 110 cases of rain, sixty-three negative values and forty-seven positive ones; while in thirty-three cases of snow, twenty-seven were positive and six negative.

Peltier's modification of the electroscope and his views on the origin of atmospheric electricity led to a series of observations by A. Cuetelet, beginning in August, 1842, at the observatory at Brussels. After some improvements in the electroscope were made, another set of observations was made in 1844, and it appeared that no negative values were observed except during rain. Indeed, negative values were rare, only twenty-three cases being recorded in four years. Passing the observations made at Dublin by Clark, in 1830, we come to those made at the observatory at Munich by Lamont, in 1850-51, with a Peltier electrometer and methods about the same as at Brussels. The monthly and annual means are given in Poggendorff's Annalen, LXXXV, 1852, pp. 494-504, and LXXXIX, p. 258, et seq. In general, the winter months show a value nearly twice that of the summer months. About the same time, observations were made at Kreuznach by Dellmann. The yearly values nearly agree, but the mean monthly values differ considerably. A minimum occurs in May and a maximum in December. The air was generally positively electrified. Smoke and fog gave high positive values, and dust caused a change from positive to negative for several hours and to a degree exceeding the positive. Rain gave sometimes high positive and sometimes high negative, the latter often when the rain had just ended. Snow almost always gave high positive.

Everett, at Windsor, N. S., made observations, generally three per day, and the results of these and later observations have been widely published, and are too well known for extended notice now. During the same time, Wislizenus, at St. Louis, Mo., made observations, and has given the annual and diurnal curves of these. Two maxima and two minima are shown in the diurnal curve and a maximum in winter. In all, Wislizenus made some 25,000 observations, and his conclusions are therefore of more weight than those of any other observer up to that time. The normal state of the air is positive, and negative is an exceptional and temporary condition. Marked disturbances were experienced at times of thunderstorms. Fog was occasionally accompanied by negative indications, but after fine drizzling rain, fog as a rule was accompanied by positive values, often very high. A full discussicn of the observations may be found in the American Meteorological Journal for 1887.

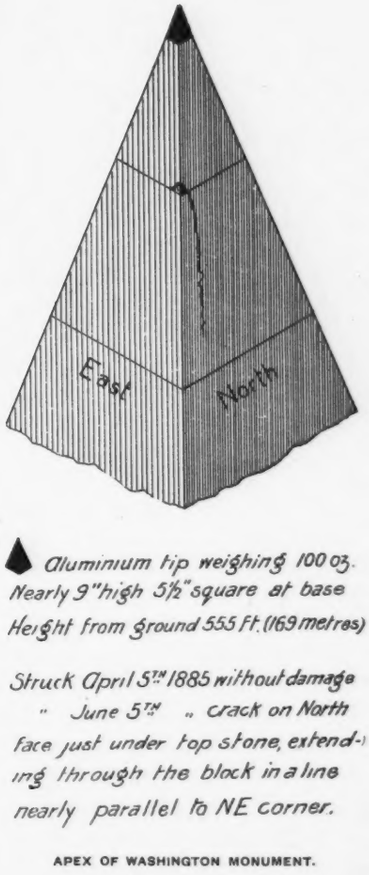
We have not space to do more than simply mention most of the other observers. W. A. Birt has given an elaborate discussion of the Kew Observations of 1845-1847 in the Report of the British Association, 1849, p. 113. At Gaud, Duprez studied the observations made from 1855 to 1864, and brings out particularly the relation to cloudiness. Palmieri, at Vesuvius, in 1850, and later with simultaneous observations at Naples and Vesuvius. found that the potential was lower at the higher statior. In this conclusion he is at variance with all other observers. Some observations that are worthy of notice were made with a water-dropper collector at Pernambuco, from October, 1876, to February, 1877. On the rare occasions in which a negative potential was recorded, there were heavy rains and more or less cloudiness. We now come to the very important observations made at Paris by Mascart and others under his direction. The apparatus was installed at the College de France in February, r878, and continuous records covering some years were obtained. In general, the potential of the air was positive. Rain was almost always accompanied by large negative values. The change in character occurs previous to the rain, and sometimes the rain is followed immediately by high positive values. A very full discussion of the observations made by the United States Signal Service is given in the Memoir of the National Academy of Sciences by Prof. T. C. Mendenhall. It is to be regretted that this discussion is not more generally known,

for there are many valuable suggestions in it concerning mechanical collectors, best forms of electromotors, proper exposures, and details of methods to be followed, of great benefit to those who are to take observations. There is also an elaborate discussion of the question, "In the present state of meteorological science, can the observations of atmospheric electricity be utilized in forecasting the weather?" A very thorough set of observations was made by Muller and Leyst, in Russia, with a Carpentier form of Mascart electrometer. The mean values for bi-hourly observations made at Pawlowsk in 1884 are given in Annalen des Phys. Cent. Obs., Part I., 1884. Other observations are those made by C. Mitchie Smith, in Madras, in 1883 and 1884; Abercromby, at the Peak on the Island of Teneriffe: Dr. Fines, at Perpignan, with photographic apparatus of the Mascart pattern, which were continued for a number of years. Roiti, Magrini, and Pasquilini have two years' complete records at Florence. Exner's extensive experiments on the potential gradient, Andree's observations near the pole while on the Swedish expedition, and the work on the Sonnblick by Elster and Geitel, bring us down to the present state of the problem.



WASHINGTON MONUMENT. STRUCK JUNE 5, 1885, AND SUBSQUENTELY

Recently experiments have been undertaken at Kew* to verify Exner's law, that a building reduces the potential of the air precisely as if it formed an integral part of the earth's surface. A portable electrometer was carried to five stations near the observatory, and the mean values of the several ratios found to be approximately constant. The meteorological elements are then discussed, and particularly the moisture, to see whether the potential gradient is so closely connected with the aqueous vapor as Exner claims. The results do not support the theory. The influence of bright sunshine in reducing the potential gradient, as shown by Elster and Geitel, seems more likely. The potential was lower after long sunshine. The evidence "in favor of a connection of high potential with low temperature is just about as strong as that in favor of a connection of high potential with little previous sunshine." Higher potential was found to be associated with higher pressure in the forenoon observations, but to a less marked degree in the afternoon observations. Adopting eleven miles as a limiting value of the wind velocity, it was found that with a


East
North
Aluminium tip weighing 100 oz.
Nearly 9" high 5½" square at base
Height from ground 555 ft. (169 metres)
Struck April 5th 1885 without damage
" June 5th " crack on North
face just under top stone, extending through the block in a line
nearly parallel to NE corner.

APEX OF WASHINGTON MONUMENT.

* Observations on Atmospheric Electricity at the Kew Observatory. By C. Chree. Proc. Royal Soc., vol. 60.

mean velocity of 19.6 miles per hour there was a mean potential of 153, and with a mean velocity of 6.8 the mean potential was 175. The author does not seem to be aware of the observations made in the United States upon similar lines. An attempt was also made to investigate the relation of the potential to cyclonic and anticyclonic weather. In five cases out of the seven considered the mean potential for the anticyclonic condition exceeded that for the cyclonic In Dr. Chree's words, "There is something to be said for the hypothesis; but individual occurrences of high potential in cyclonic weather and of low potential in anticyclonic weather were not infrequent."

The recent paper of J. Elster* and H. Geitel is a most comprehensive review of recent investigations in the subject. For painstaking and systematic study of the potential as influenced by water vapor, sunlight, dust and height, it cannot be excelled.

The views of von Bezold and Arrhenius concering a photo-electric action of the solar radiation have been in part confirmed by these investigators. It has been experimentally shown that the sun's rays act on certain substances in such a way as to cause a loss of negative electricity. Our authors make the potential gradient vary with exposure to ultraviolet light. The marked disturbances occurring with precipitation are considered as disturbances of the normal field. They also think that Palmieri is right in his statement that whenever negative electricity is observed rain falls close by. Sohncke and Luvini have shown how dry ice crystals were positively electrified through friction with dust-formed water, and Maclean and Goto, and more recently Lenard and Kelvin, have discussed the electrification through falling water. "When waterdrops strike on a fixed moist substratum or a larger water surface, the surrounding air at the time of impact shows itself as negatively electrified." And our authors think, with Lenard, that it is very probable that the negative values so prevalent during rainy weather are in part due to this. With the building of mountain observatories, the electric observatories, the electric phenomena of the air, and more especially the silent discharges, come more readily under our observation. Elster and Geitel themselves have collected a number of observations relating to the appearance of St. Elmo's fire on the Sonnblick. It would seem that the phenomena are closely connected with climatic conditions and are to be studied in their development precisely as thunderstorms.

Elster and Geitel have rendered a great service to future students of atmospheric electricity by clearly pointing out the difference between the normal field or fair-weather electricity and the *accidental* field, if it may be so called, when the electrical measurements are greatly influenced by dust, snow, clouds, precipitation, whirling air or smoke, spattering water, etc. "Certainly it is an improvement," they say, "to diminish the influence of the lower dusty strata of air through the employment of kites, as introduced by McAdie at Blue Hill, and later by Weber at Kiel, though it is questionable if the advantage is not too dearly bought by the impossibiiity of determining the height." Marked improvements have been made in kite methods since these words were written. Another important matter touched upon by our authors is the circulation of electricity from the earth into the atmosphere and back again to earth. Theories are not wanting, but experimental determinations are. It is not improbable that a link in the chain of processes may be the aurora, and investigations in this direction are therefore greatly desired. Through such will the relation between the electric and magnetic fields be brought out. The following problem is suggested for investigation: "*How are the magnetic elements and the electrical currents of the air related?*"

Professor Schuster in a recent lecture* has given a most interesting resume of the experimentation of Franklin's time with the modern lecture apparatus for studying the conduction of gases. The question of the breaking down of the air as an insulating medium is touched upon, and the effect of light and of the discharge itself considered. Electric sparks are liable to succeed each other along the same path, and Schuster thinks this points to a higher conductivity of the air along the path of the previous discharge. Schuster also thinks that the location of the positive charge, corresponding to the earth's negative charge, can only be ascertained through the agency of balloon and kite experiments. "Observations made up to heights of about 1000 feet seem to indicate a strengthening of the electric field, i. e,, the fall of potential per meter is greater at a height of, say, 200 meters than on the surface of the earth." The observations of Dr. Leonhard Weber and Dr. Baschin are referred to, the former as showing how the fall of potential at a height of 350 meters was six times that at the earth's level; and the latter showing that at a height of 3000 meters no fall could be determined, while at 760, 2400 and 2800 meters, respectively, the fall in volts per meter was 49, 28, and 13, respectively. It seems, therefore, likely that the lines of force of the normal electric field of the earth end within the first 10,000 or 15,000 feet. Schuster advances the somewhat startling view that the semidiurnal variation of atmospheric electricity is connected with "the same circulation in the upper regions of the atmosphere which shows itself in the corresponding changes in pressure." He refers to Exner's formula:

$P=\frac{A}{I+kp_0}$, where $A=1300$, $k=13.1$, p_0 = pressure of aqueous vapor present, in centimeters, and P=the electric force; and notes the agreement between vapor pressures 0.23 and 0.05. It is the amount of vapor, and not the humidity, which controls. Elster and Geitel's ultraviolet radiation relation to electrification and amount of aqueous vapor present is also alluded to.

* Review of Recent Investigations in Atmospheric Electricity. By J. Elster and H. Geitel. Extract from Part II of the Report of the Chicago Meteorological Congress, August, 1893, pp. 510-522.

* "Atmospheric Electricity." Lecture delivered before the Royal Institution f Great Britain, February 22, 1895, by Professor Arthur Schuster.

SOME MEASUREMENTS OF THE POTENTIAL OF THE AIR.

Experiments at the Smithsonian Insiitution.—In 1886 some investigations on atmospheric potential were undertaken at Washington, under the direction of General Hazen, Chief Signal Officer, and more immediately under the supervision of Professor Mendenhall. Experiments were made by the writer at the tower of the Smithsonian institution. The electrical history of a summer afternoon thunderstorm may be read in the following record of the potential changes. June 14, 1886; a showery and oppressive morning; the wind very light and coming in feeble puffs; southwest at 11:30 a. m.

Time	Volts +	Volts −	Remarks
11:30a m.	78	.....	
35	54	.....	
40	60	.....	Wind southwest, light.
45	36	.....	
50	54	.....	
55	54	.....	
58	78	.....	
12:40 p. m.	66	.....	
45	72	.....	
50	3	.....	
52	.....	66	
55	.....	138	Wind from south-by-east, puffs, no particular cloud conditions.
57	.....	168	
1:00	.....	210	
02	.....	90	Very light rain began at 1:02 p. m.
03	.....	42	
05	120	.....	
97	198	.....	
09	216	.....	Distant thunder at 1:09. Clouds in
10	210	.....	west looking like advance guard of
11	198	.....	thunderstorm, with some blue sky,
12	186	.....	however.
13	156	.....	
14	132	.....	Thunder at 1:13:25. Clouds also in
15	108	.....	northwest. Thunder from 1:16:20 to
16	108	.....	1:17:40. Rain commenced 1:17; lasted
17	96	.....	5 seconds.
18	96	.....	
19	78	.....	
20	72	.....	Rain commenced 1:20:15, light. Ended
21	54	.....	1:22.
21−2	54−72	.....	Thunder at 1:22:20.
22 2	54	.....	
23	30	.....	
24	30	.....	
25	30	.....	
26	12	.....	
27	6	.....	Very light rain commenced 1:27:30.
28	.....	12	
29	.....	54	
30	.....	78	
32	.....	192	Very distant thunder.
33	.....	246	
34	.....	240	
35	.....	252	
38	.....	234	
39	.....	180	Light rain.
40	.....	174	Rain ended 1:39:20.

Experiments at the top of the Washington Monument.—The electrical history of a thunder storm as indicated by an electrometer at the top of the monument is very interesting. The following is a description of one of many experimnnts thus made:

May 6, 1887. We are 500 feet above the city streets. It is a warm afternoon and looking from the west windows of the monument one sees through the near haze around Arlington and the Virginia hills far to the southwest a patch of dark cloud. It needs little experience to pressage a thunder squall. It is about twenty miles away and will reach us in about forty minutes, perhaps in less time. At ten minutes to three o'clock the clouds are overhead, and this is the last we shall see of the world oustide until the storm is over, for it is necessary that the heavy marble doors be swung to. All is dark in the monument save for the beam of reflected light traveling along the ground glass scale. The little mirror reflecting the light is attached to the electrometer needle, and in this way the most minute movement of the needle is made known. From the south window the nozzle of the water dropping collector protrudes through a small opening. The wind rises, and we notice the needle moving steadily toward the point marked 1000 volts, positive. This means that the pull upon the air is steadily increasing. Suddenly the needle flies to the other side of the scale and we know that the air, like a piece of overstretched rubber, has snapped and given way under the strain. The pull is now negative, i.e., in an opposite direction, and now the needle dances and we hear outside

Time	Volts +	Volts −	Remarks
1:43 p. m.	.....	150	
44	.....	120	
45	.....	72	
48	.....	24	
50	12	.....	
55	66	.....	
58	78	.....	
2:00	78	.....	
01	78	.....	Rain commenced 2:01 p. m.
05	78	.....	
09	90	.....	
10	90	.....	
13	72	.....	A very heavy cumulus cloud is moving
15	84	.....	up toward the place of observation
17	96	.....	from the river.
20	90	.....	
21	66	.....	
23	72	.....	
25	66	.....	
30	48	.....	
35	48	.....	
40	54	.....	
45	30	.....	
50	30	.....	
55	24	.....	
57	0.0	.....	
58	.....	12.0	Bright and shining; large, white cum-
3:00	.....	114.00	ulus clouds in southwest, southeast
02	.....	150	and east, but the northwestern hori-
			zon is black and evidently a storm is
			coming.
03	.....	186	First thunder 3:03:15 to 3:03:40; thunder
04	.....	228	30:07:30 to 3:07:42; calm; thunder
05	.....	276	3:09:10 to 3:09:13.
	.....	288	
06	.....	300	
07	.....	312	
08	.....	.....	
09	.....	348	Thunder 3:10:08 to 3:10:10.
10	.....	360	
11	.....	390	
12	.....	396	Thunder 3:12:25 to 3:12:27.
13	.....	420	
14	.....	444	
15	.....	438	Thunder 3:15:30 to 3:15:32.
16	.....	444	
18	.....	480	Thunder 3:17:30.
	.....	504	

the rumble of distant thunder, all indicating the approach of the disturbance. Nearer comes the storm, if we may judge from the rapid fluctuations of the needle, Values of 3000 and 4000 volts are common.* The deflections are at times greater than the scale limits. With every flash of lightning we catch the fleeting reflection of a little spark in the electrometer. On one occasion running a wire from the iron-work to within a small distance of the collector we counted more than 100 ⅛-inch sparks in a minute. If we place the eye close, but not too close, to the little peep-hole through which the nozzle goes, we shall see the stream of water twisting and breaking into spray, and each time it lightens, becoming normal quick as the flash itself, but only to rapidly twist and again distort itself.

Increase of potential with elevation.—Some idea of the normal rate of increase of potential with elevation can be gained from the following table:

TIME, A DAY IN NOVEMBER. THE TWO STATIONS ABOUT 500 FEET AND 45 FEET, RESPECTIVELY

Time	Monument	Signal Office	Difference
	Volts	Volts	Volts
1:30 p. m...	400	216	684
1:32 p. m...	888	246	642
1:34 p. m...	900	216	682
1:36 p. m...	862	246	616
1:38 p. m...	875	240	636
1:40 p. m. .	825	222	603

THE ELECTRICITY OF THE UPPER AIR AS MANIFESTED IN AURORAL DISPLAYS.

One of the great mysteries of the upper air is the aurora. No paper treating of the electrification of the atmosphere can be complete without a more or less imperfect knowledge of this most beautiful of all electric displays. The following brief review is from an article published in the *Century Magazine* for October, 1897, somewhat modified to suit the requirements of the present publication:

WHAT IS AN AURORA.

On the first day of January, 1892, Dr. Brendel and Herr Raschen reached the Alton Fiord, Lapland, to remain several months, studying the auroral displays and magnetic disturbances. Brendel succeeded in photographing the aurora, a very difficult thing to do, as all who have attempted it know. The deep reds, which are so beautiful to the eye, make little impression on the photographers's plate, and the light itself is generally feeble and flickering. Not unaptly have the quivering auroral beams been called "merry dancers." Even the bright displays are hard to photograph, as we may see from an entry in General Greely's notebook on January 21, 1882: "A most beautifnl aurora," he says, "with intense light, at times sufficiently bright to cast my shadow on the snow. Rice exposed a sensitive plate without effect, but the constantly changing position of the aurora may have been the cause."

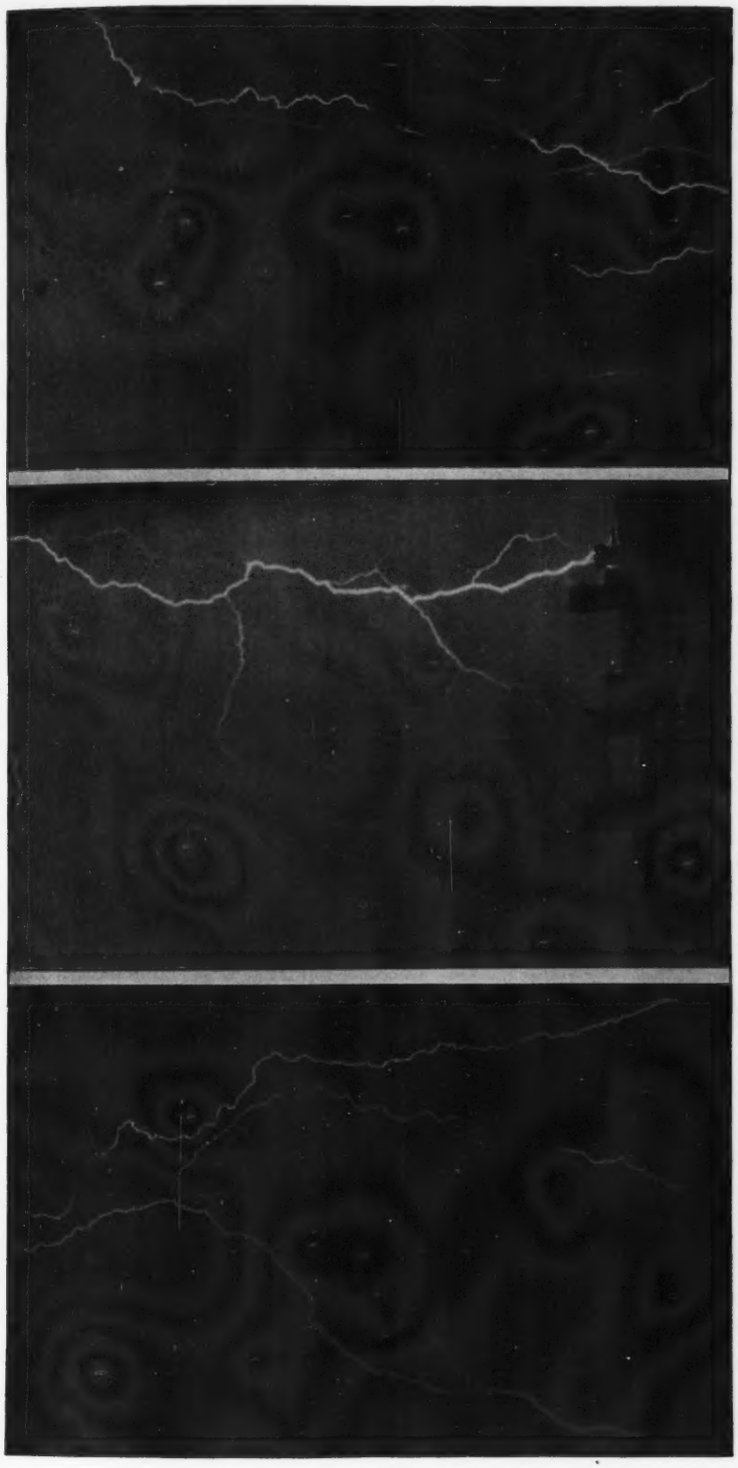
Once the sun-spot period was clearly established, it was only necessary to ransack chronological liats of auroras to find how intimately auroras and sun spots were connected. Three patient investigators, Wolf, Fritz and Loomis, soon proved that auroras were most frequent when sun spots were most numerous. The next step was to find individual relations. One bright September morning thirty-seven years ago, Carrington and Hodgson, separately studying the face of the sun, saw a remarkable outburst near the edge of a great spot. For some days the magnetometers at Kew showed unusual perturbation, and for several nights magnificent auroral displays were seen over two continents. It was long thought that a violent magnetic disturbance occurred *simultaneously* with the outburst, but recent examination of the records disproves this. In 1872 Professor Young noticed a disturbance in the chromosphere in the neighborhood of a sun spot, and upon asking the astronomers at Greenwich and Stonyhurst to examine their magnetic records, it was found that great disturbances had occurred about that time. Ten years later the astronomer at Greenwich sent out a message that read something like this: "Remarkable sun spot now visible. * * * Area of whole spot, $\frac{247}{100000}$ of the sun's visable surface." Try to imagine what this means, and fancy yourself on the sun while that tremendous storm was in progress. We know that here on earth there was a magnetic storm with auroral displays that beggars description. Beginning a little before daylight on November 17, 1882, not a wire of the Western Union Telegraph Company could be used for three hours. The market quotations could not be sent. Late in the afternoon the trouble seemed to decrease, but at night there was a brilliant auroral display, and all telegraphic service was again interrupted. A very short circuit from Boston to Dedham showed the disturbance equally with other circuits. The cables to Europe and the wires to Chicago were alike unworkable. A message was sent from Bangor to North Sidney, 700 miles, by cutting out the regular batteries and allowing the energy of nature to have its own way. The current was just as strong as if a hundred cells had been at work. At Albany the switchboard was ignited; and in telephone offices generally the annunciators dropped continually. Switchboards and wires were burned at Chicago. Incandescent lamps were illuminated in St. Paul, and even in far San Francisco the telephone operators were nigh distracted. Over half of North America, across the Atlantic, and on over northern Europe it seemed as if legions of etherial demons were busy inciting electric and magnetic apparatus to strange and mischevious antics.

It so happened that about the pole that year were clustered representatives from twelve nations. The Russian international expeditions were at the Lena Delta and Nova Zembla; the Norwegian at Bossekop; the Dutch Dicksonhavn; the German at Kingua Fiord; the Finnish at Sodankyla; the Swedish at Spitzbergen; the Danish at Godthaab; the Austro-Hungarian at Jan Mayen; and the British at Fort Rae. France had two stations in the

* At the Eiffel Tower values as high as 10,000 volts have been obtained.

antarctic region, and our own country had the well-known Lady Franklin Bay party under Greely, and the Point Barrow party under Ray.

November 14-19, 1882, was a period never to be forgotten by these Arctic prisoners. While we at home saw the display of a decade, the observers of the frozen north, turning their eyes southward or westward or eastward, saw visions glorious by *day* as well as by night, and felt perhaps some measure of recompense for their isolation and peril. Coming out of their dark quarters, they were startled and at first blinded, and General Greely writes: "The curtain appeared at one time so near our heads that Gardner and Israel speak of having unconsciously dodged to avoid it." In Ralston's diary is the entry: "The aurora appeared so low down that I raised my hand instinctively, expecting to bathe it in the light;" and Brainard relates a like impression. What a pity that under such conditions no electrometric apparatus was available. With Thomson water dropping collectors and multiple-quadrant electrometers, records of the electrification of the lower air could have been obtained, and a few more threads raveled out from nature's tangled skein. Some observations of the potential of the air, made by Andree, who was a member of the Swedish party at Cape Thordsen, Spitzbergen, seem to show that the electric potential diminished very rapidly during an aurora, and in fact became negative. As is well known, this same Andree has lately attempted to reach the pole in an air ship. Not the least valuable result of the adventure will be the increase in our knowledge of the electricity of the air in polar regions. We shall learn a little more about the height of auroras. We know now that while they are from fifty to seventy miles high in latitude 50°, the height decreases as we approach 68°. At Godthaab, Paulsen measured many with theodolites, and found that some were less than two-fifths of a mile high. Hildebrandsson and others have seen auroras below the clouds. Such results lead us to believe that the time is ripe to suggest a new classification of auroral displays. It has been further noticed that the colorless and quiescent auroras were *not* necessarily coincident with magnetic disturbances, while those of brilliant color and rapid change were. Many so-called auroras are probably what the Germans would call *wetter leuchten*, and akin to silent lightning.



CLOUD AND MULTIPLE FLASH
From photograph by McAdie

DESTRUCTIVE FLASH
From photograph by McAdie

MULTIPLE FLASH
From Popular Science Monthly, 1893, McAdie

Our little planet unquestionably responds to solar disturbances. The intense auroral displays that occur simultaneously over continents are, one may think, answering signals to the messages flashed from the sun through the quivering æther. But we may also have our own little storms and disturbances; and while appearances may be similar, the phenomena are of differ-

ent origin. Some of the difficulties and discrepancies which have been met in tabulating sun spot, magnetic, and auroral phenomena can be thus explained. One wise remark by Professor Young should not pass unnoticed. "The solar tumult," he says, "may be the brother and not the father, of our aurora." But this much is plain: The phenomena are closely allied, and mastery of the terrestrial displays will enable us to reach out and attempt the conquest of the solar ones. It may be frankly said that the man of science feels that the aurora has baffled his scrutiny.

PROTECTION FROM LIGHTNING.*

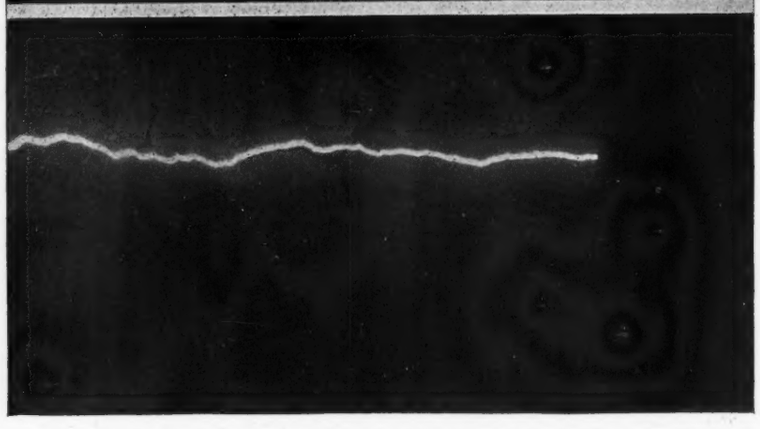
At the Aberdeen meeting of the British Association for the Advancement of Science, Sir William Thompson made the remark, "If I urge Glasgow manufacturers to put up lightning rods, they say it is cheaper to insure than to do so."

This was the answer given by practical business men, concerned only with questions of profit and loss, to the foremost physicist of our time; and their answer will serve as fairly representing views widely held, founded upon the double belief that the risk from lightning is not so very great and the protection afforded by the present methods not sufficiently certain to warrant implicit confidence and justify the necessary expense.

The recent remarkable experiments of Dr. Oliver Lodge, in his lectures before the Society of Arts, opposing and to some degree directly contradicting the empirical rules of the Lightning Rod Conference, have given support to the belief that the protection was uncertain. Indeed, realizing that his work might be misinterpreted, Lodge has stated "an idea at one time got abroad that my experiments proved existing lightning conductors to be useless or dangerous; this is an entire misrepresentation. Almost any conductor is probably better than none, but few or no conductors are absolute and complete safeguards. Certain habits of lightning rod practice may be improved and the curious freaks or vagaries of lightning strokes in protected buildings are intelligible without any blame attaching to the conductor; but this is very different from the contention that lightning rods are unnecessary and useless. They are essential to anything like security."†

What Lodge's brilliant experimental work does show is that the momentum of an electric current can not be overlooked in a lightning discharge. The old "drain-pipe" idea of conveying electricity gently from cloud to earth must give place to the new proposition, based upon recent discoveries, that even draining off must be done in an appropriate way to be effective. To illustrate, the rocks and trees upon a mountain side may influence and determine the course of a mountain stream, but even a good sized channel would not suffice to carry off safely an avalanche, or control the path of a landslide; so with lightning. In the last four years we have learned, through the work of Hertz and others, that when an electric current flows steadily in one direction in a cylindrical wire its intensity is the same in all parts of the wire; but if the current be of an oscillatory character, i. e., a current which rapidly reverses its direction. the

MULTIPLE FLASH
From Scribner's Magazine, A. Binden

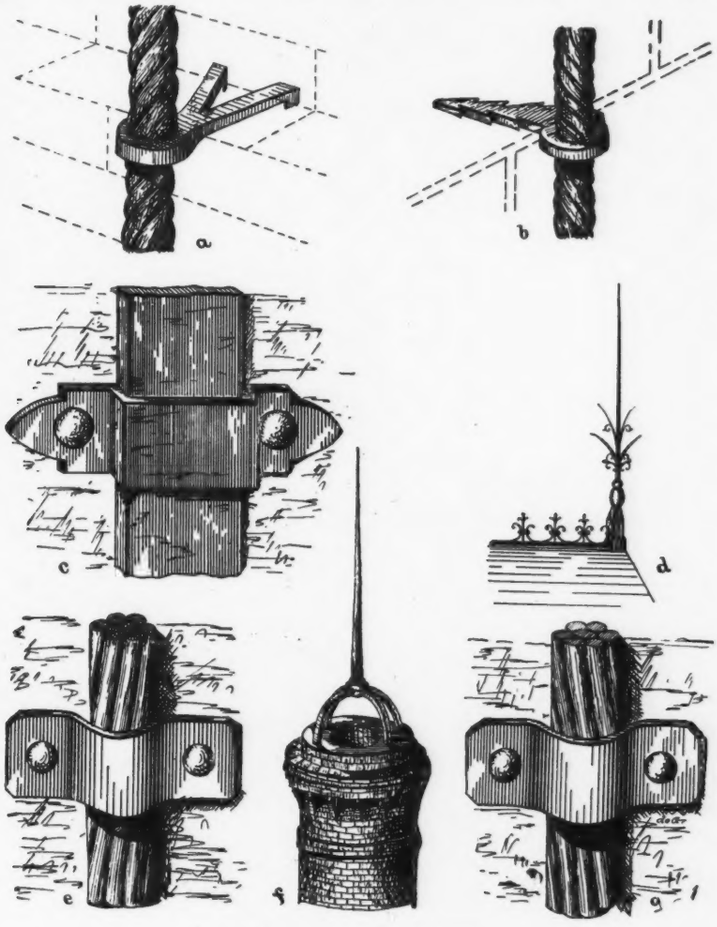


IMPULSIVE RUSHAND SO-CALLED DARK FLASHES.
From Popular Science Monthly, McAdie

* From Bulletin No. 15, U. S. Weather Bureau.

† Page VI. Lightning Conductors and Lightning Guards."

condition no longer holds, and if the alternations are very rapid the interior of the wire may be almost free from current. If lightning then be a discharge of an oscillatory character, it may happen that the current down the lightning rod would be only *skin deep*. The experiments of Tesla and Elihu Thompson with currents of great frequency of alternation and very high potentials open the door to systematic study of discharges such as the ordinary lightning flash. In daily work currents of this type are coming more and more into prominence, and the time is not far distant when the lightning flash will be studied as an electrical discharge of this character. Protection entirely adequate for such discharges will then be forthcoming. Indeed, the reasons why present methods occasionally fail are now understood, and the proper remedies apparent.



CONDUCTORS AND FASTENING
From Anderson, and Lightning Rod Conference

LIGHTNING CONDUCTORS.

Beyond doubt Franklin proved his case that lightning rods were efficacious in the protection of buildings. Buildings with conductors when struck by lightning suffered little damage compared with those without protectors.

EFFECT OF THE ACTION OF LIGHTNING UPON A ROD.

The chief defects likely to occur are blunted points and breaks in the continuity of the connection. The function of a lightnieg rod is two-fold; first, that of conducting the charge to earth, and second, the prevention of a disruptive discharge by silent neutralization of the cloud electrification. The latter explains why a rod terminates in a point, and likewise why points in good connection with the ground are always *desirable* upon buildings. Indeed, points are somewhat like small water pipes connected with a large reservoir. If you have enough of them and a sufficient time you may drain the largest reservoir. Furthermore, when some sudden rise or flood occurs in the reservoir, these minute drains may be of service in keeping the height of the water down.

In the case of lightning the points are the small escape pipes, the layer of air between cloud and earth the retaining wall, and the cloud electrification—or charge—the overflowing or destructive element. A large conductor, be it rod or tape, on the other hand is more like a large main or waterway, which has its gate shut until the flood is imminent. Then the gate is suddenly opened and we try to compel the torrent to keep to the provided path. We trust in its ability to safely hold the flood. Generally it does. In perhaps nine cases out of ten, the lightning conductor, if it be such a one as we will describe later, does carry the flash to the earth; but there are cases where the discharges have been heavy and overflows have resulted. To carry the lightning flash "the lightning conductor should offer a line of discharge more nearly perfect and more accessible than any other offered by the materials or contents of the edifice we wish to protect." To prevent the discharge "the conductor should be surrounded by points." These quotations are from the Report of the Lightning Rod Conference.

The statement that lightning always follows the path of least resistance, as commonly ununderstood and stated, needs modification. True it is, that when the air is strained by being subjected to the electrifications of cloud and earth, the weakest spot gives away first, and this is apt to be in line with some small elevated knob or surface; but it is equally true, and is perhaps the more general case, that when a really vigorous disruptive discharge does occur, it is somewhat, as Dr. Lodge aptly puts it, like an "avalanche." As a matter of fact, we find from the study of actual cases where buildings have been struck, that lightning often disregards metallic surfaces and points. What we should first know is, whether the condition is to be one of "steady strain,"* or "impulsive rush"* discharge. In the case of "steady strain," the metal is apt to influence the path of discharge: in the

* Terms used by Professor Lodge.

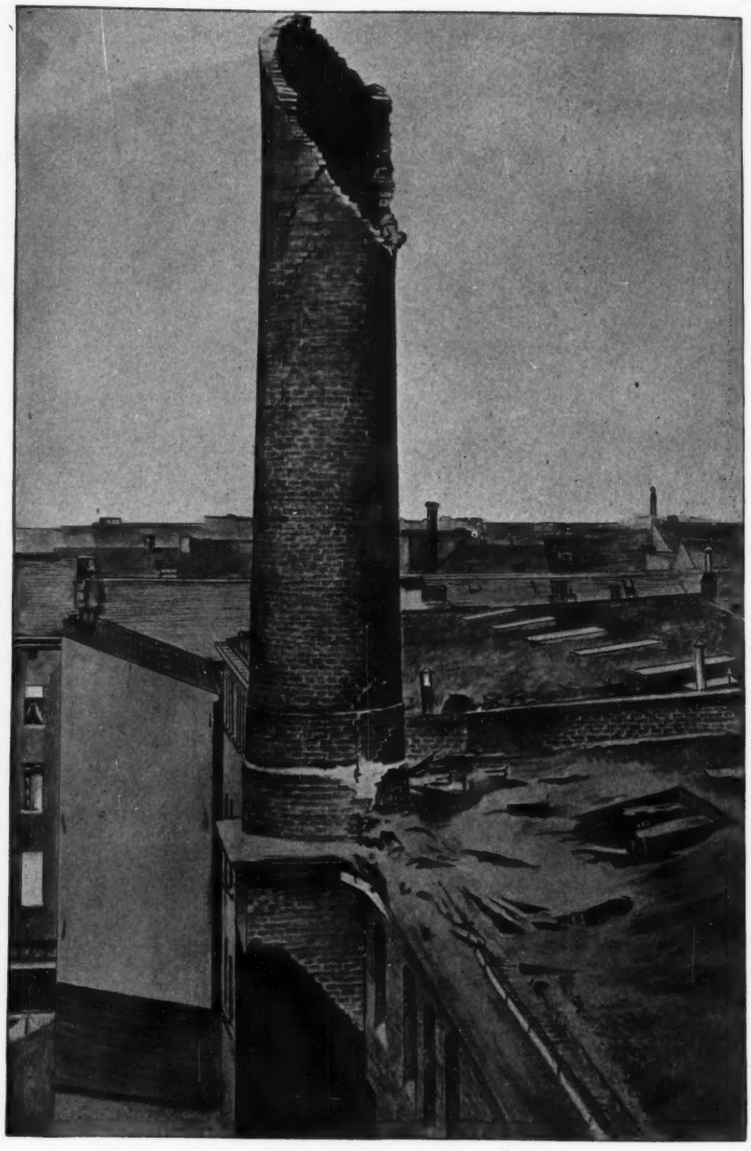
case of an "impulsive rush" discharge, even *points* seem to lose their efficiency and become of little use.

In a letter* of an old British admiral there occurs a description of his being called upon to approve some specifications for a lightning conductor to be erected on a certain lighthouse. He was himself a believer in the "surface" theory of Harris; but thought that, to make sure, he would go and consult his friend Faraday. Faraday, who saw only the question of conductivity in the problem, said very positively that the solid rod was better than the tube (which gives greater surface with less copper), and that *solid volume was everything*, superficial area nothing. Moreover, if Harris says otherwise "then, he knows nothing whatever about it." The admiral straightway approved the solid rod conductor for the lighthouse. Within two or three days he met Harris, and bringing up the question was told by Harris "*surface* area is most important, and if Faraday says otherwise, then he knows nothing whatever about it."

Up to a certain point Faraday was right, a copper rod an inch thick is capable of carrying almost any flash of lightning, and is undoubtedly a great protector, but if, as we have reason to believe, the core is seldom given a chance to carry the current, why have it? The views of Sir W. Snow Harris, based as they were upon close study of many thousand cases of lightning action, are finding in the experiments of today the confirmation so long needed.

While not going into details regarding this question of the shape of the rod, let us emphasize the fact, so recently brought out, that if an electric current flows steadily in one direction in a cylindrical wire, as shown by Hertz, but that with a current of an oscillatory character, i. e., a current which rapidly reverses its direction, this condition no longer holds and if the direction is altered very rapidly the interior of the wire, in our case the lightning rod, may be almost free from current.

In 1882 appeared the report of the Lightning Rod Conference; in many respects the most important contribution to the literature of the subject yet made. While so many foreign governments, and in particular France; had by means of officially constituted boards taken a governmental interest in the protection of the people from the dangers of lightning, the English speaking people of the world aside from the few directions officially issued for the protection of magazines and lighthouses, remained without any authoritative utterance upon the subject; and while this conference itself did not have strictly official sanction, it carries, from the character of its makeup, a weight certainly as great, if not greater, than an official board. It was simply a joint committee of representative members of the Institute of British Architects, the Physical Society, the Society of Telegraph Engineers and Electricians, the Meteorological Society, and two co-opted members. As might be anticipated from such auspices, the report is an excellent one, and must stand for years as the embodiment of the most widely gathered information and well considered decisions. The report is emphatically one based upon *experience*.

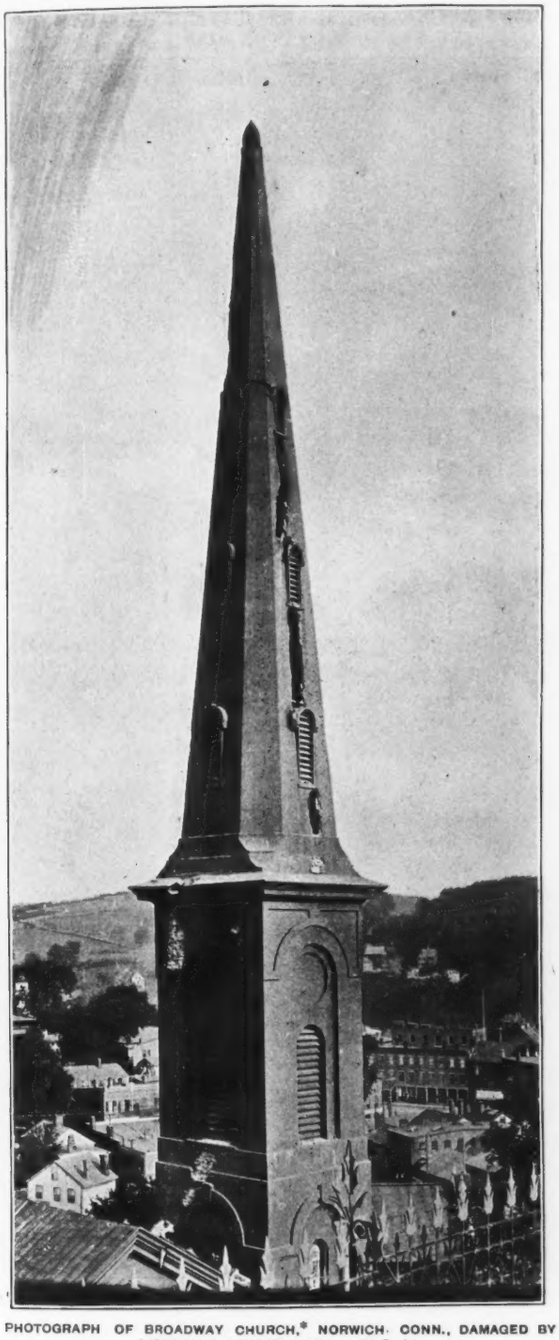


CHIMNEY, STRUCK JULY 29, 1890
From Elec. Zeits., Greibel

The famous free-for-all discussion which occurred at the British Association Meeting in 1888, so far as our judgement goes, simply proved that the decisions of the conference could not at present be disregarded. As the president of the meeting, Sir William Thompson said, "we have very strong reason to feel that there is a very comfortable degree of security, if not absolute safety, given to us by lightning conductors made according to

* See report of Lightning Rod Conference.

the present and orthodox rules." There are one or two further features to which attention may be called. There are some very prevalent misapprehensions with regard to lightning. For example: that it never strikes twice in the same place: that the most exposed place is always struck; that a few inches of glass or a few feet of air will



PHOTOGRAPH OF BROADWAY CHURCH,* NORWICH, CONN., DAMAGED BY LIGTHNING JULY 29, 1894, 1:30 P. M.
Photographed by Mr. F. J. Moulton.

serve as a competent insulator to bar the progress of a flash that has forced its way through a thousand feet of air, etc. These are alluded to in the following general directions.

* The spire is of brick, 198 feet high, with a cap of brownstone. It was not protected by a lightning rod. See *Scientific American* September 8, 1898.

ERECTION OF RODS—GENERAL DIRECTIONS.

1. Few questions have been so thoroughly discussed from practical as well as theoretical standpoints as that of the certainty of the protection afforded by properly constructed lightning rods. Ordinary dwelling houses in city blocks have not the need for rods that scattered houses in the country, and especially if on hillsides, have.

2. Use a good iron or copper conductor. If the latter, one weighing about six ounces to the foot, and preferably in the form of tape. If iron is used, and it seems to be in every way as efficient as copper, have it in rod or tape form and weighing about thirty-five ounces to the foot. "A sheet of copper constitutes a conductive path for the discharge from a lightning stroke much less impeded by self-induction than the same quantity of copper in a more condensed form," whether tabular or solid. —Sir William Thompson.

3. The nature of the locality will determine to a great degree the need of a rod. Places apart but a few miles will differ greatly in the relative frequency of flashes. In some localities the erection of a rod is imperative; in others hardly necessary.

4. The very best ground you can get is, after all, for some flashes but a very poor one; therefore do not imagine that you can overdo the matter in the making of a good ground. For a great many flashes an ordinary ground suffices, but the small resistance of $\frac{1}{10}$ ohm for an intense oscillatory flash may be dangerous. Bury the earth plates in damp earth or running water.

5. "If the conductor at any part of the course goes near water or gas mains, it is best to connect it to them. Wherever one metal ramification approaches another, it is best to connect them metallically. The neighborhood of small-bore fusible gas pipes and indoor gas pipes in general should be avoided."—Lodge.

6. The top of a rod should be plated or in some way protected from corrosion and rust.

7. Independent grounds are preferable to water and gas mains.

8. Clusters of points or groups of two or three along the ridge rod are recommended.

9. Chain or linked conductors are of little use.

10. Area of protection. Very little faith is to be placed in the so-called area of protection. The committee that first gave authority to this belief considered that the area protected by one rod was one with a radius equal to twice the height of the conductor from the ground. Many lightning rod manufacturers consider that the rod protects an area of radius equal to the height. The truth is that buildings are struck sometimes within this very area, and we now hold there is no such thing as a definite protected area.

11. Return shock. Some uncertainty exists on this point. The so-called "return stroke" is caused by the inductive action of the charged cloud on bodies within its influence, and yet some distance away from the place of the direct discharge. As explained by Lord Mahon, who first called artention thereto, the sudden return of

the body charged inductively to a neutral condition, following the equalization at some distant place, is the cause of the return shock. We are beginning, however, to see more clearly into the character of the stress in the dielectric, preceding and during flashes, and it is only a question of time before the use of this term, "return shock," will be abandoned. Of far greater import are the terms "recoil kick" and "alternate path," as shown experimentally by Lodge to exist.

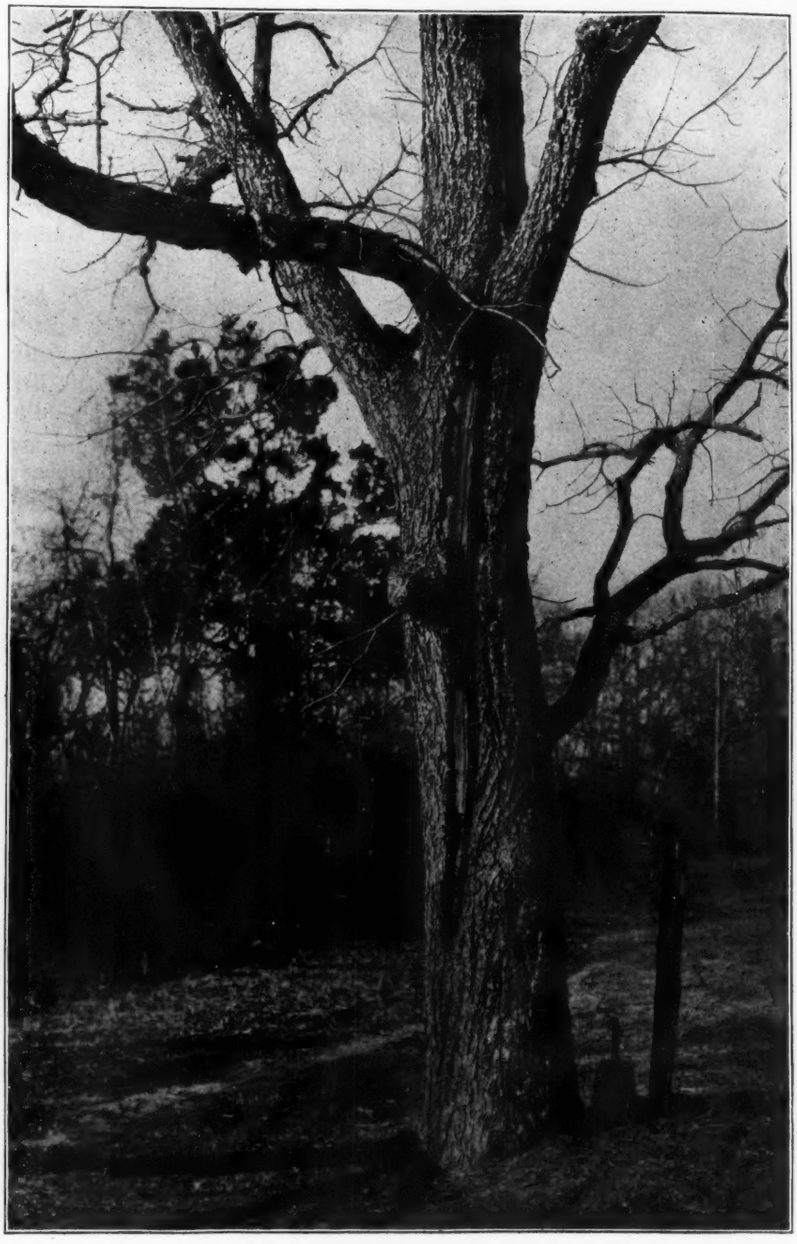
12. Upward motion of stroke. There is no reason to doubt that the discharge takes place sometimes from earth to cloud. That is to say, that while we now consider a lightning flash as something like the discharge of a condenser through its own dielectric, made up of excessively frequent alternations say something like 300,000 times per second, the spark, or core of incandescent air, may seem to have had its beginning at the earth's surface. That is to say, the air gap breaks down first at a point near the earth.

13. Indifference of lightning to the path of least resistance. Nearly all treatises upon lightning up to within very recent times, assumed that lightning always followed the path of least resistance. "It is simply hopeless to pretend to be able," says Lodge, "to make the lightning conductor so much the easier path that all others are out of the question." The path will depend largely upon the character of the flash.

14. Any part of a building, if the flash be of a certain character, may be struck whether there is a rod on the building or not. Fortunately, these are exceptional instances. The great majority of flashes in our latitudes are not so intense but that a good lightning rod, well earthed, makes the most natural path for the flash. We have many instances, however (not to be confounded with cases of defective rods), where edifices, seemingly well protected, have been struck below the rods.

15. Paradox of paradoxes, a building may be seriously damaged by lightning *without having been struck at all.* Take the famous Hotel de Ville of Brussels. This building was so well protected that scientific men pronounced it the best protected building in the world against lightning. Yet it was damaged by fire caused by a small induced spark near escaping gas. During the thunderstorm, some one flash started "surgings" in a piece of metal not connected in any way with the protective train of metal. The building probably did not receive even a side flash. This is, therefore, a new source of danger from within, and but emphasizes the necessity of connecting metal with the rod system.

16. Lightning does sometimes strike twice in the same place. Whoever studies the effects of lightning's action, especially severe cases, is almost tempted to remark that there is often but little left for the lightning to strike. No good reason is known why a place that has once been struck may not be struck again. There are many cases on record supporting the assertion.



EFFECT OF LIGHTNING STROKE ON A WALNUT TREE
Photographed by A. J. Henry

17. As lightning often falls indiscriminately upon tree, rock, or building, it will make but little difference sometimes whether trees are higher than adjoining buildings.

18. It is not judicious to stand under trees during thunder storms, in the doorway of barns, close to cattle, or near chimneys and fire places. On the other hand, there is not much sense in going to bed or trying to insulate one's self in feather beds. Small articles of steel also do not have the power to *attract* lightning, as it is popularly put, or determine the path of discharge.

19. Unnecessary alarm. Just in advance of thunderstorms, whether because of the varying electrical potential of the air or of the changing conditions of temperature, humidity and pressure, and failure of the nervous organization to respond quickly, or to whatever cause it may be due, it cannot be denied that there is much suffering from depression, etc., at these times. It is, perhaps, possible that these sufferings may be alleviated.

20. Finally, if you should be in the vicinity of a person who has just been struck by lightning, no matter if the person struck appears to be dead, go to work at once and try to restore consciousness. There are many cases on record proving the wisdom of this course; and there is reason for believing that lightning often brings about suspended animation rather than somatic death. Try to stimulate the respiration and circulation. Do not cease in the effort to restore animation in less than one hour's time. For an excellent illustration of a case of severe lightning shock and recovery, due, it would seem, to prompt action by the medical gentlemen present, all who are interested may consult the *Medical News*, August 11, 1888. A number of cases corroborative of this view are on record in various medical journals.

BURR OAK SHATTERED BY LIGHTNING
Photographed by Frank Woodmancy

Apart from this, many people suffer greatly from alarm during the prevalence of thunderstorms, somewhat unnecessarily, we think. Grant even that the lightning is going to strike close in your vicinity. There are many flashes that are of less intensity than we imagine, discharges that the human body could withstand without permanent serious effects. Voltaire's caustic witticism "that there are some great lords which it does not do to approach too closely, and lightning is one of these," needs a little revision in these days of high potential oscillatory currents. Indeed, the other saying, "Heaven has more thunders to alarm than thunders to punish," has just so much more point to it, as it is nearer the truth. One who lives to see the lightning flash need not concern himself much about the possibility of personal injury from that flash.

No matter what method for respiration you use, it is important to maintain the warmth of the body by the application of hot flannels, bottles of hot water, hot bricks, warm clothing taken from bystanders, etc.

Firmly and energetically rub the limbs upward, so as to force the blood to the heart and brain. If an assistant is present let him attend to this. Remember above all things that nothing must interrupt your efforts to restore breathing.

When swallowing is established a teaspoonful of warm water, wine, diluted whisky, or warm coffee should be given. Sleep should be encouraged. In brief:

1. Make the subject breathe by artificially imitating the respiratory movements of the chest.
2. Keep body warm.
3. Send for a physician.

Of the visible effects of lightning stroke upon the human body little more can be said than that sometimes burns, usually superficial, have been noticed, frequently red lines and markings, which are localized congestions of the small blood vessels of the skin. These, from their irregularities and branchings, have led to the fanciful idea of photographs of trees. etc.

In conclusion it may be said that lightning frequently causes a temporary paralysis of the respiration and heart beat which, if left alone, will deepen into death, but, intelligently treated, will generallv result in recovery.

LIGHTNING ARRESTERS.

In his "Experimental Researches,"* Faraday describes the miniature house he had built to test the question of shielding bodies from electrical influences without. It was a hollow cube twelve feet high, wound around completely on the outside with wire. He says:

"I went into this house and lived in it; but though I used lighted candles, electrometers and all other tests of electrical states, I could not find the least influence upon them or indication of anything particular given by them, though all the time the outside of the cube was powerfully charged and the large sparks and brushes were starting off from every point of its outer surface."

Maxwell, in 1876, suggested to the British Association a plan, based on the experiments of Faraday, for protecting a building from the effects of lightning by surrounding it with a cage of wire or rods. The problems which the electrical engineers of today are called upon to solve are different from those of the time of Faraday or even Maxwell. Extensive light and power plants must be guarded with great thoroughness. Cables and telegraph lines have for years been provided with various forms of lightning arresters, but only in the past few years has the action of lightning been studied with some degree of success. The chief function of all of the old style lightning arresters has been to sidetrack the flash, switching it out of the main circuit and leading it as quickly as possible to earth. Cable, telephone and telegraph line protection have been systematically studied of late years by Professor Oliver L. Lodge and others. In Lodge's excellent book upon lightning conductors and lightning guards the theory of lightning arresters is given at length. Satisfactory apparatus has been devised upon sound scientific principles for the protection of the delicate galvanometers and other instruments employed on cable, telephone and telegraph lines. The principle applied may be stated in general terms to be "a succession of air-gap paths to earth, connected up by coils of well insulated wire, across the turns of which the lightning, weakened as it is by the first air gap to earth, is not able to leap."*

In protecting electric light and power plants, there is the further and very important question of preventing the formation of an arc across the air gaps or at any point on the circuit, thus short-circuiting these heavy currents. Many devices exist for automatically rupturing the dynamo arc thus formed. Some have many

EFFECT OF LIGHTNING STROKE ON AN OAK
Photographed by A. J. Henry

* Paragraph 1173.

* Lightning Conductors and Lightning Guards, p. 419.

points of excellence, but the ideal protector must not only give a proper spark gap and also rupture any arc that may form, but better still should be so designed as to prevent the formation of an arc.

Alexander J. Wurts has for many years studied the problem of protecting electrical apparatus with a great measure of success. It is known that discharges do not pass readily through coils of wire, and Wurts has found that properly constructed choke coils connected in the circuit and used with arresters forms a good combination for protecting against lightning. While experimenting along these lines Wurts discovered that if the electrodes of an arrester were made of zinc the short-circuiting arc would not be maintained. There are five metals—zinc, bismuth, antimony, cadmium and mercury—which are non-arcing metals. For alternating currents these non arcing arresters are quite reliable. For direct current circuits an arrester is used in which the high potential discharge is made to pass over a circuit discharge plane, *e. g.*, a pencil line upon a block of marble, and by means of a second block firmly bound to the first, the vapors from the electrodes, upon which the arc feeds, are suppressed. Wood is now used instead of marble, as at first, and shallow grooves take the place of the pencil line. It is also necessary to slot the upper block at right angles. This arrester is also a discriminating arrester, in that it allows disruptive charges to pass freely, but does not allow a dynamo current to follow. These are the points dwelt upon by Wurts in a lecture given before the Franklin Institute in June, 1905.

FUNDAMENTAL PRINCIPLES OF THE NON-ARCING RAILWAY LIGHTNING ARRESTER.

The fundamental principles of this device are based on the following facts:

1. That a static discharge will leap over a non-conducting surface, such as glass, wood, marble, etc., more easily than through an equal air space. If a pencil mark be drawn over this non-conducting surface the discharge will take place still more readily.

2. That a dynamo arc in order to be maintained must be fed by the fumes or vapors of its electrodes—conversely, therefore, that in order to avoid the formation of a dynamo arc between electrodes means must be taken to prevent the formation of these conducting fumes.

The electric crack—An electric spark which springs across an air gap does not pass like ordinary moving matter gently pushing the air aside. Its passage is so instantaneous that the air is shattered, so to speak; the spark crashes its way through the air like a bullet through a pane of glass. If, however, the air be previously split—electrically split—the spark will pass with ease. A pencil mark over ground glass or a charred groove in a wooden surface forms an electrical crack or entering wedge through the air so that an electric discharge finds a much easier path over this surface and through this electrical crack than it does when it is forced to bore its own way through the air medium.

Discharge by disruption—In the non-arcing railway lightning arrester the discharge is caused to pass between two brass electrodes separated by half an inch and over narrow grooves burned into a block of lignum vitæ. It must not be understood that this charred surface acts as a conductor in the ordinary sense of the word. The discharge takes place not by conduction, but by disruption, leaping betweed the electrodes and over the charred surface, the latter acting simply as an electrical crack through the air and thus greatly assisting the passage of the electrical discharge; neither does this charred surface leak dynamo current, for the ohmic resistance between the electrodes is more than 50,000 ohms. If now a solid lignum vitae block be firmly screwed down over the charred grooves and metal electrodes it will be impossible for conducting vapors to form and the device is at once a non-arcing lightning arrester.

CHOKE COILS FOR ALTERNTING CURRENT CIRCUITS.

A lightning discharge is of an oscillatory character and possesses the property of self-induction; it consequently passes with difficulty through coils of wire. Moreover, the frequency of oscillation of a lightning discharge being much greater than that of commercial alternating currents, a coil can readily be constructed which will offer a relatively high resistance to the passage of lightning and at the same time allow free passage to all ordinary electric currents.

Any coil will afford a certain amount of impedence to a disruptive discharge. Experience has shown, however, that there is one form which offers at once the maximum impedence to the discharge with the minimum resistance to the generator current.

Choke coils of this type connected in the circuit, when used in connection with non-arcing lightning arresters, offer a very reliable means of protecting well insulated apparatus against lightning. This arrangement is particularly well suited for protecting station apparatus in power transmission systems. Coils can, however, be used to advantage on the line for the protection of the more expensive translating devices.

Tests made under actual working conditions indicate that for ordinary commercial voltages effective protection is obtained with four choke coils in series in each wire, with four lightning arresters intervening.

ELECTRIFICATION OF THE ERIE RAILROAD.

It has been known for a long time that the Erie Railroad has been studying the possibilities of electric traction for its suburban service in the neighborhood of New York City, but that the equipment of these lines has been delayed for a number of reasons, among them the construction of an open cut in place of the present Jersey City tunnel and the rearrangement of the terminal station at Jersey City. Nevertheless, the directors of the company have recently authorized Vice-President Graham to organize an electrical commission to study the subject in detail, and it is thought that one of the branch lines, either the Northern Railroad of New Jersey or the Greenwood Lake division, will be operated with electricity next year.

The Journal of ELECTRICITY, POWER and GAS
DEVOTED TO THE CONVERSION, TRANSMISSION and DISTRIBUTION OF ENERGY.

PUBLISHED MONTHLY BY
The Journal of Electricity Publishing Company
Room 532, Rialto Building, San Francisco, Cal.
Telephone Main 1264.

Official Organ of the Pacific Coast Electric Transmission Association.

Yearly subscription: Domestic, $2.00; Foreign, $3.00; Single Copies, 25 cents.
Subscriptions can not be begun with back numbers.
Manuscripts submitted must be accompanied by postage to insure return.

ADDRESS ALL COMMUNICATIONS AND MAKE ALL REMITTANCES PAYABLE TO THE JOURNAL OF ELECTRICITY PUBLISHING COMPANY

This paper is a member of the National Trade Press Association.

Entered as second-class matter at the San Francisco Post Office, August 15, 1899.
Entered as *The Electrical Journal*, July, 1895. Entry changed to *The Journal of Electricity*, September, 1895.

VOLUME XVI MARCH, 1906 NUMBER 3

EDITORIAL.

PROTECTION FROM LIGHTNING.

On the Pacific Coast less attention has been given to the problem of protection from lightning than in other portions of the country. Along the coast we have comparatively few electrical disturbances, and these as a rule are seldom violent. Nevertheless we are not exempt and it is only a part of wisdom to be prepared for emergency. There is a further reason why the subject should now be discussed on this Coast. The rapid spread of long distance transmission lines and the invasion of the Sierra for high level power bring the question closely home, because the mountain districts are regions where thunderstorms are both frequent and destructive.

During the past year the electrical journals of the East have given much space to discussion of various protective devices used on transmission lines. The discussion has been one-sided, however, in that it was restricted to the behavior of lightning arresters. Electrical engineers naturally view the subject from the standpoint of men behind the breastworks, that is on the defensive. It is plain that a great deal can be learned by going outside the breastworks, that is from the standpoint of the meteorologist and aero-physicist. Granted that it is important to know of the behavior of the air gap in a certain type of arrester, is it not equally important to know something of the nature of lightning in general? If we would ascertain how to best handle the induced charges on lines we should know a little about atmospheric electricity. While it is good to be able to protect the line, prevent arcing and short circuits by proper choke coils in parallel with a spark gap and by means of tell-tale papers in the gaps, as Neall has done, to keep tab on the arresters and in a way measure the frequency and intensity of atmospheric charges, it would possibly be more enlightening to have records of cloud charges during thunderstorms and the atmospheric conditions determining these accumulations of electrical energy. In its broadest sense, the problem of the cloud charge is like that of accumulated snow on a mountain top. Disregarding for the present *how* the snow got there, we know that it may move in mass, an avalanche, and that none of man's protective measures will avail much. So, we have certain intense lightning discharges, and experience shows that even with good horn arresters acting, a number of poles are smashed and the system put out of action. W. S. Franklin has suggested the use of a series of three-foot terra cotta pipes painted before final firing with platinum chlorid, but it is doubtful if this even would be effective in case of direct stroke. In the second place the snow on the mountain top may be dissipated by wind action and evaporation. So, too, we have a constant gentle neutralization of electrical strain. Ordinary static discharges can be discharged gradually and without any resulting interference. In the third place the snow may melt rapidly enough to form small water courses. So with the electrical energy, there are disturbances entering the line which if not properly disposed of in time by the introduction of multiple spark gaps, reactive coils or series resistances, will cause trouble directly and indirectly.

In brief then, we ought not to expect any arrester to be able to meet the various kinds of trouble caused by lightning. And for this reason, we must know more about the electricity of the air before we may hope for adequate protection. It will not be out of place to say that the best possible protection may yet be devised along entirely different lines from those now followed, namely by methods looking to the prevention of an accumulation of charge in the atmosphere. As far back as the time of Franklin a hint of this was given in the clear recognition of the fact that one of the dual functions of a lightning rod was to help dissipate the induced earth charge. Hence the clusters of points on rods. Some recent work which we fear is for the most part unknown to electrical engineers, is suggestive in connection with the question of dissipation of electrical charge by electrons. Elster, Geitel, Ebert, Caspari, Czermak, Palazzo and Linke are working along this line.

It is quite appropriate then that the question of lightning protection should be considered from the broadest possible standpoint.

THE GENERAL PUBLIC VS. THE PUBLIC SERVICE CORPORATIONS.

In almost all communities public sentiment is antagonistic to the public service corporations, and from time to time waves of protest, and of complaint, bring the subject prominenlty to the front. At the present time, this condition of affairs in San Francisco is growing somewhat acute, and it seems not untimely to attempt a dispassionate review of the situation, to discriminate as to the merits of the

complaints made, and to point out, so far as may be done, those actions and laches on the part of the corporations, which engender the rancor so often displayed.

Methods of high finance, employed in successive reorganizations, have produced a condition of affairs, so far as San Francisco is concerned, where the par value of bonds and stock of the companies is not only in excess of the *bona fide* cost of the actual construction, but largely in excess of the cost of construction that would be essential to render equivalent service. We believe the accuracy of this statement cannot be successfully disputed, unless a possible exception be made in favor of water supply, where natural conditions, as well as the art of man, are controlling factors. Even here, there are available sources of supply, other than those utilized at present, which, if they are reported by competent engineers, lead to the inevitable conclusion that even water may not be excepted.

This condition of affairs brings about a feeling in the community, that rates are being charged to enable the corporations to pay interest and dividends on exorbitant capitalization, and an agitation is commenced for lower rates. The daily press is, as a rule, only too quick to pick up such an agitation, and public sentiment is still more inflamed.

It is difficult for a private citizen to see any reason why he should be charged rates for service rendered by the quasi-public corporation which will enable them to pay interest on fictitious investment. The average man will unhesitatingly acknowledge the justice of rates that cover actual cost, and a fair return on actual investment.

The contention is often made by those arguing in favor of reduced rates, that the valuation, on which returns should be allowed, should be limited to the amount for which a new plant could be installed to render equivalent service. There is a measure of injustice in this to the corporation. Communities grow rapidly, and their needs and requirements grow in equal proportion. Unless rates are charged which will enable the original cost of apparatus, that may become obsolete or worn out, to be extinguished within its period of useful life, the original cost must be carried in the investment account, and due allowance be made for it in establishing rates. Otherwise the corporation suffers an injustice.

Too often the municipal authorities take the stand, that because a competing company has come into the field, which having a lower investment charge, can furnish service at a lower rate, therefor the legal rate of charge should be fixed at a point that will enable the new company to pay the actual cost of the service it renders, plus an interest charge on its investment.

Under the California law, any individual or corporation, may enter any city or town where no municipal plant exists, and engage in the business of supplying gas, electric light and water. Capital invested in such companies is given no protection against competition, and at the same time the rates, which may be charged, are fixed and established by the municipal authorities. In strict equity, it would seem that capital invested in such enterprises should receive protection, and that at the same time the interests of the citizens should be safeguarded by establishing rates that are reasonable and fair.

The method of regulating this matter adopted in England, seems more rational than our own. The exclusive right to furnish service in a certain section is given to a corporation, and both its investment and the rates to be charged are fixed by the municipal authorities. Should increase or replacement of plant become necessary, the additional investment must be approved by the same power before it can be made.

Such a method effectually prevents what is so often seen in this country, *i. e.*, the inflation of capitalization which so inevitably follows the absorption of one company by a competitor. Municipal ownership is often suggested as a remedy for all the evils of high rates, and over capitalization, but the discussion of this question would cover such a wide range, that it cannot be taken up here.

Certain definite charges and complaints are at the present time being urged against public service corporations.

The United Railroads Company is charged with failing to provide sufficient cars to accomodate all its patrons during the rush hours, and that those who travel at that time are subjected to overcrowding, and are unable to get seats. Certain of the city officials have gone so far as to threaten action that would compel the railway company to provide a seat for every paying passenger, or to compel them to refuse to permit cars to be overcrowded.

That such overcrowding does exist is patent to everyone who travels during the rush hours. It must also be evident to anyone familiar with the character of the American people, that to refuse to permit passengers to board cars because all seats are occupied would precipitate a riot at once.

It is also evident that, at least on lower Market Street, more cars than are now being used cannot be operated with present facilities. Converging lines deliver their cars to Market Street, and it is no uncommon sight to see a solid blockade of cars at the foot of Market Street for two or more blocks, and the turn table working at limit speed, in the effort to dispatch them on the return trip.

With whom rests the blame for the situation at this particular point?

We may imagine the following conversation between an "Indignant City Official," and the manager of the United Railroads Company.

Ind. City Official. "Why don't you provide sufficient cars to properly accomodate passengers on Market Street during the rush hours?"

Mgr. Un. Rys. "We are running as many cars now as possible, in fact we cannot empty, load, and turn the cars around at the foot of Market Street as fast as they arrive."

Ind City Official. "Can't you adopt some other method of handling the people off and on the cars, and use something that will be quicker than the turn table?"

Mgr. Un. Rys. "If we had a free hand we could and would do so, but we are not permitted to adopt the overhead trolley system of electric operation on Market Street which would enable us to put in a system of loops at the Ferry Building, and instead of converging all the traffic from McAllister, Hayes, Haight, Castro and Valencia Street lines, some of it could be diverted to the Ferry by way of Mission Street, etc., etc."

Does the above help to answer the question? We fear not. It does however seem possible that the United Railroads could do a great deal to ameliorate conditions, if met by the city authorities in an effort to accomplish this end.

There are worse things than a properly constructed trolley line on Market Street.

It is being urged, and strongly too, that present rates for gas and electric current should be reduced.

San Francisco consumption of these two commodities has grown with enormous rapitity during the past few years, and at a rate far greater than the growth of population. The price of gas has steadily declined, as was but just that it should, with cheaper gas making material, and greater volume of business. The public, and the municipal authorities as well, should, however, bear in mind that there is a limit beyond which reduction may not go without injustice to the company.

It should also be borne in mind that much of the gas and electric light sold in the outlying and sparely settled districts, is served at an actual loss.

That such a large majority of the manufacturing establishments find it to their best interests to buy current to drive their shops, is sufficient proof that the rates for this class of service are just and reasonable.

Many people cannot understand why the price for supplying current for lighting a residence should be any higher than that which is supplied to a manufacturing establishment for operating its motors. They fail to take cognizance of the fact that practically all residences require current at the same time, and for only a very few hours out of the twenty-four. In the meantime, the electric company must be in readiness to supply the demand at any moment, and this with no opportunity of storing during period of light demand for use in the evening.

Electricity must be produced at the immediate moment of demand, and in this respect is comparable to no other line of manufacture.

The corporation supplying water to the community of San Francisco, has been the object of constant attack and criticism of the severest sort. Our only comment with reference to it is contained in the following paraphase of an old saying, and which applies with equal force to all the corporations mentioned.

"T'were well to inquire whether it be of God, man, or the devil, or partly God, partly man and partly devil."

The basic complaint which may be justly urged against practically all of our public utility corporations may be summed up in the one word OVER-CAPITALIZATION.

STEAM LOCOMOTIVES VERSUS ELECTRIC MOTORS

In the last issue of THE JOURNAL we spoke at length on electric railroad development in this State and took the ground that the electric railway would prove the true benefactor to California. It is to be expected that the steam railroad owners would offer some objection and declare that the electric line can never be a serious competitor with the steam road. This, however, is the function of the electric line and as far as can be judged the electric line is not to be regarded as a sort of helper to the steam line.

Cheap transportation is what the railroads want, and the electric line offers the solution of that much debated problem. We have high authority for believing in the future of the electric line, as J. A. F. Aspinall, of the Lancashire and Yorkshire Railway, at the recent International Congress, said that his company did not go into the electrification of their Southern line for the purpose of saving money but that they were compelled to make the change owing to the difficulty in handling the vast crowds during the rush hours at their Liverpool terminal. In other words Mr. Aspinall said that the steam locomotive was incapable of handling a big rush in a short space of time, and that electric traction was the only feasible way. This is an admission that we can take without reserve, as it comes from an English railroad man, and it is well known that new ideas are not adopted at random in Great Britain. In this country it has been proven that as soon as the motive power was changed into electricity faster schedules were introduced. Statistics show that on the elevated electric lines in Chicago and on the Metropolitan line in London a maximum speed of twenty-five miles per hour was obtained in ten seconds with electric traction, while it required thirty-three seconds for the same acceleration with steam locomotives.

This is not mere guess work, but is the result of actual trials. As far back as 1902 tests were made between steam and electric motives by B. J. Arnold, of the New York Central. An equal weight of cars were given to both engines and the measurements related not only to power consumed but to speed attained, and the conclusion was reached that the electric motor would accelerate more rapidly, for the same weight on drivers, than the steam locomotive, and that covering the same distance in the same time, a lower maximum speed could be used with less energy consumption with the electric motor. During last April further tests were made which confirmed the decision reached by Mr. Arnold.

It has been thought that the electric motor would, or could, only be used for the hauling of passengers, but this is not the case, for experts declare that the electric locomotive is even more useful than the steam locomotive for transportation of freight, and for this reason it has merits which will eventually commend itself to the favor of railroad men. The argument advanced in favor of the electric locomotive can be thus briefly summarized: In hauling heavy freight trains on grades the steam

locomotive is soon limited by steam supply from the boiler, and speed is rapidly reduced to six or eight miles an hour, and on long grades the volume of traffic which can be hauled at such a slow rate of speed must necessarily be small. With electric locomotives, having the same tractive force, it would be possible to operate at speed three times as fast, or at twenty miles an hour, and the capacity of the road would be vastly increased.

This is putting the matter in a nutshell. If the electric motor can handle a big rush of passengers more speedily than the steam locomotive and can also haul freight over grades more safely than the steam locomotive, it looks as if the steam engine had at last met its match.

HOME AND FOREIGN NEWS.

A New Water Tube Boiler

A new water tube boiler has recently been invented by J. M. Colman, of Everett, Wash. An important feature of the device is the provision of manholes in the ends of the headers, side tubes, and steam dome. This provides for the ready inspection and cleaning of the various parts of the device. Provision is also made for firing from either end or from both at the same time, so that the firing end can be changed at will to suit convenience or for blowing out soot from all sides.

A New Book On Alternating Currents

The publication by a firm identified with popular literature (Harper and Brothers) of so technical a work as "Alternating Currents, Their, Theory Generation and Transformation," by Alfred Hay, D. Sc., M. I. E. E., etc., illustrates the great growth of interest in electrical matters. This book of Mr. Hay's contains the maximum of information in the minimum space. This subject matter is treated in a masterly manner, each point of development adequately working is strongly emphasized.

Electrical Exports

The total value of electrical exports from the United States for the year 1905 was, $13,057,677. This is the largest no record. The following table shows the total value of electrical exports for the last three years:

	1903.	1904.	1905.
Electrical appliances	$4,751,545	$ 4,363,992	$ 5,648,435
Electrical machinery	5,104,502	6,679,766	7,409,242
Total	$9,856,047	$11,039,758	$13,057,677

Details as to the destination of electrical exports from the United States can only be given of goods classed as electrical machinery. Considering, therefore, electrical machinery only, British North America was the largest purchaser from the United States in 1905, having held that position also in 1904. Previous to 1904 the United Kingdom had always held first place, but the value of its imports from this country has gradually fallen off from $2,924,989 in 1902 to $885,095 in 1905. Japan was the second largest purchaser during the year 1905, and Mexico was third. In 1904 Japan suddenly jumped from a minor importer of our electrical machinery to the third from the top, and the 1905 figures show a considerably increase over 1904. It is also interesting to note that the exports to Cuba show an increase from $35,195 in 1904 to $190,337 in 1905.

Carnegie Building for Engineers

When Andrew Carnegie so generously offered to give a building to the engineering societies of this country, one condition was that these societies should provide the land upon which the building should be erected. The condition was accepted and to the American Institute of Electrical Engineers fell the task of raising $200,000 for this purpose. A considerable amount has been raised, to which have been added recently two generous donations. One is a gift of $25,000 voted to the fund by the directors of the General Electric Company and the other is the personal check of President C. A. Coffin, of the same company, for $5,000. These two gifts bring the fund up to $100,000, which is one-half the total amount to be raised.

Steam Turbines at Low Pressure

The ability of the steam turbine to utilize the lower part of the steam cycle makes it feasible to operate a turbine economically at steam pressures which would not be suitable for reciprocating engines. This feature was pointed out some time ago, Rateau, in particular, having devoted considerable attention to utilizing, in the low-pressure turbine, the exhaust of a reciprocating engine. The turbine is made to step in between the engine and the condenser, and converts into power a large part of the energy of the exhaust steam which would otherwise be carried off in the cooling water. In this way, without in any way increasing the consumption of fuel, a considerable increase in the output of the plant may be effected.

200th Anniversary of Benjamin Franklin.

The 200th anniversary of the birth of Benjamin Franklin has just been celebrated. It is somewhat striking that at this time Franklin's single fluid theory which for years past has been accepted merely as an interesting attempt to explain electrical phenomena by the assumption of an electrical fluid, should now, a century and a half after he proposed it, be again mentioned in connection with the latest physical discoveries. Since we know the electron only through its electrical properties, and since the electrical condition of matter might be explained by the excess or deficiency of electrons, Franklin's theory fits the case. Any such explanation must, of course, be only tentative. It merely signifies that another cycle in scientific research has been completed.

Electrical Installation in European Mines

There have been recently installed in many European mines electrical apparatus for chain and locomotive haulage, hoisting ventilating. Electric power for driving the main ventilator has been chosen in preference to steam, at the "Gluckauf" mine at Sondershausen; this has been done although the plant is in the immediate vicinity of a set of boilers. Fewer hands are needed by this installation than formerly. Another interesting electric ventilator plant is that at the "Gabrielle" Mine of the Grand Ducal Mining Board at Karwin (Austria.) The Paulus Hohenzollerngrube, in Silesia, has an underground haulage plant on the endless-chain system. A large winch has been erected at the "Emma" mine belonging to the mining company "Werschen-Wissenfelser." Electric rock drills are used in the Charles-Ferdinand gallery at Gross-Hettingen, at the Amanda workings, at Wolf Dietrich, Gewerkschaft Hercynia, Vienenburg, near Harzburg, and at the coal mines of Gottessegen, at Lugan, near Chemnitz. Electric locomotives for the haulage of all materials, either to the shafts for removal from the mine, or else to the outside of the mine have been installed at the "Tollinggraben" mine, the gauge being 480 millimeters and continuous current being used. Another haulage locomotive is installed at the "Gewerkschaft Hercynia," near Vienenburg.

A Battleship Driven by Steam Turbines

The launch of the English battleship Dreadnought at Portsmouth, England, the largest and most powerful man-of-war ever constructed, will direct attention to a great achievement. When ready for sea this vessel will displace 18,500 tons, but her size is the least remarkable feature. The details of the Dreadnought's construction still remain a secret.

In one respect the Dreadnought will be unique. She will be the first battleship in the world to be driven by turbines, and since the success of the Hon. Charles A. Parsons' invention was demonstrated so conspicuously by the Cunarder Carmania, the courage evinced by the British Admiralty in making this bold departure will occasion no feelings of anxiety. It is claimed that in comparison with reciprocating engines it is economical both in respect to the staff to tend it, the coal consumed, the expenditure of oil and the space occupied in a ship, while the absence of great bearing parts should lead to economies in repairs. It is, moreover, much simpler in construction than the present type of machinery, and tends to reduce the vibration, thus giving the gunners a more stable platform from which to fire. It is not yet known what pattern boilers the Dreadnought will have, but they will be water tube. In the space available probably no others could produce sufficient steam to drive this huge massive sea sentinel through the water at nineteen knots an hour. Messrs. Vickers, Sons & Maxim are manufacturing the turbines.

Prize for Current Limiting Device

A prize contest has been organized by the Hydraulic Power Syndicate of Grenoble, France, relating to a much-needed device for use in electric light or power stations. On the system of wiring which distributes current to the subscribers, each of the branch circuits is established so as to provide for a certain power whose maximum is determined in advance, and the arrangement is made with the subscriber either by contract or meter. It often happens that the maximum of current is exceeded for more or less time, and this causes trouble upon the whole system which the station supplies. It will be of value to have a method which will allow of notifying the subscriber in the first place, and if he pays no attention, of obliging him to return to the conditions of his contract, this without annoying surveillance on the part of the central station. The proposed current-limiting device is to work at a higher power than 5,000 watts and on all kinds of current. It is to give a signal as long as possible before it commences to operate; then it limits automatically the current on the branch line, working every time the proper current is exceeded. It can be set back again, but leaves each time an indication of the resetting.

A complete description is to be sent before April 1, 1906, to the Siege Social du Syndicat des Forces Hydrauliques, 62 Boulevard Haussmann, Paris, also (if accepted) two apparatus, which are to be tested on the line and in the laboratory. A prize of 2,000 france ($500) is to be awarded for the best device.

Electrical Clocks

A very extensive system of electrical clocks with wireless transmission is being introduced in Vienna. According to reports in the Austrian and German daily press the following particulars may be stated:

As is well known, a great number of cities possess a clock system where electrical currents are used to operate the various clocks from a central station. A special drawback of all of these is the fact that they are designed only for either alternate currents or battery currents, thus entailing the use of a special current generator. This inconvenience has been obviated by Carl Morawetz of Vienna, who some years ago constructed an electrical pendulum which, by the joint action of some non-oxidizing contacts and ingenious mechanisms, constitutes an electrical clock to be operated by direct currents from the lighting mains. Now, the idea suggested itself to use a similar standard clock to operate a number of secondary clocks, say the public clocks of a great city. Though a similar scheme might be carried out in practice it would involve a large cost due to the laying out of an extensive network of cables, while its working would be interfered with by any earth-work, apart from the induction effects produced by any power and light cables immersed in the ground.

RAIL BONDING.

IN the early days of electric railway construction with few and light cars in operation the matter of a return circuit was given but little thought, but gradually as the number of cars and weight of load increased, especially on long lines where it was desired to attain a high rate of speed, the matter of securing a return path of low resistance became a serious consideration.

At first small secondary wires were run and connected with the rails at frequent intervals but a closer study of the problem with a demand for greater capacity at less cost led to the use of the track rails for a return circuit and this is now conceded to be the only practical plan. To utilize the track rail for this purpose it became necessary to join their ends at every joint with a bond that would make and maintain a good electrical connection. The real function of rail bonds, therefore, is to join the ends of rails so as to form an unbroken circuit through them for the return of the current after it has passed through the car. There is probably no item in the construction of an electric road which represents as small an initial investment as rail bonds and at the same time so directly affects the cost of operation and maintenance. They may be made to increase or seriously to menace the net earnings of any road. The scale and oxide of iron on the surface of the rails and splice bars prohibit the making of even a fair electrical contact between the two, and even if the surfaces could be kept clean and bright the contact would be seriously impaired by the excessive vibration.

The first bonds used were commonly known as "lace bonds" and consisted of small iron wire about the size of the present signal system bonds, threaded through holes in the web of the rail. Then to increase the capacity the iron wire was displaced by copper wire with the ends riveted into the rail web or wedged with channel pins. Pieces of old trolley wire were frequently used for this purpose. Another scheme was to use plain strips of copper bolted to the rails or held in place by the joint plate. Then various forms of plug terminal bonds were designed, some of the best known and most extensively used being those with terminal studs arranged at right angle with the body or flexible portion of the bond. These terminals were inserted in holes drilled or punched in the web or flange of the rail and compressed or expanded to fill the hole by means of a tapered steel pin driven through the hollow terminal or by hand screw or hydraulic compressors. The latter exerting a maximum pressure of approximately one hundred tons have doubtless shown the best results for this type of bond.

The iron and copper wire bonds mentioned were long since considered obsolete, so for the purposes of this article need receive no further consideration.

The design of the flexible portion of any bond is determined very largely by the position in which the bond is to be installed. For instance, if it is meant for application as a concealed bond under the joint plates it must be designed to accommodate itself to the space available under such plates. It too often happens that the whole space is occupied by the bond with no allowance for the movement of the joint plates or the variations allowed rail manufacturers from the dimensions given on blue prints, the result being a broken and distorted bond after very limited service. The broken strands of such bonds protruding from under the fish plates is a familiar sight to track men. It is the old story of a number eight foot in a number seven boot. It has frequently happened that the flexible portion of bonds even where the space did not limit the length was made too short to provide for the motion of the rails, the expansion and contraction of which are the most talked of and perhaps the least destructive elements. The depression and creeping of the rails and the excessive vibration, due to the passage of the rolling stock, are most disastrous to rail bonds, especially on elevated structures or poorly ballasted surface roads.

Any one attempting to design a rail bond should be fully conversant with the conditions to be met. To use one form of bond for all classes of service is about as sensible as prescribing the same medicine for all ills.

In certain processes of manufacture where intense heat is used to unite the terminals to the body of the bond it has been found that the effective life of the metal was impaired by the high temperature so that the strands became brittle and broke easily, especially near the terminals. Even at this great sacrifice it is seldom that perfect contact between the terminals and flexible portion of the bond is obtained by such a process, as the surface of the copper oxidizes very rapidly at high temperatures and so makes the fusing or welding of the metals extremely difficult.

The means available for detecting inefficient bonds after they are installed are so crude and unreliable that few roads have yet done much testing for this purpose. The result is that thousands of miles of road are now in operation where the loss of current through poor bonding would probably astonish the most liberal and broad minded stockholder if he were cognizant of the facts. Such losses are profitable to the coal dealer but may seriously impair the dividends of the road.

Inspection of a good many thousands plug bonds as they came from the manufacturer showed that the terminal studs were very irregular and not in true cylindrical form. Further inspection of the same type of bonds after they had been in use less than a year showed grave imperfections. Even the marks of manufacture on the terminals has not been obliterated by the process of installing, the end nearest the body of the bond in many cases having no contact whatever with the rail, despite the claim so strenuously made by several manufacturers that the means supplied by them will so expand the terminals as to completely fill the hole in the rail and thus prevent corrosion. In the majority of cases corrosion had taken place to an astonishing degree. Whether an electrolytic action had contributed to this condition it is difficult to say, but it is doubtless true that electrolysis is very destructive on all direct current systems. At all events it can be safely said that the most common cause for impaired contact is oxidation.

It has been held that grounding the rails at frequent intervals would materially increase the capacity of the return circuit. Copper plates connected with the rail by means of wires and immersed in streams of water were used for this purpose. It has been shown that these devices were of no value in increasing the capacity of the return circuit while they did frequently contribute to destructive electrolytic action, especially when in the vicinity of water mains or gas pipes.

The maximum thickness of the average rail web or flange and the diameter of plug which can be compressed limits the contact area possible to secure between the cylindrical plug and the rail so that it is vital even on the smaller sizes of bonds to have the surfaces clean and bright and free from moisture, for moisture is non compressible.

Various forms of plastic alloy bonds have been offered from time to time and some of them used quite extensively. In one form the terminals of the copper bond and the holes of the rail were treated with a coating of amalgam and held in contact by pressure. In another form a mass of amalgam surrounded by a cork washer was squeezed between the rail and splice bar, the surfaces of both being thoroughly cleaned and coated with amalgam before the washer was put in place. Thus the splice bar became a part of the circuit with two bonds in series at each joint. It has been found that these bonds deteriorated very rapidly and it is safe to assume that any bond depending either partially or wholly on tight fish plates and bolts for a contact is doomed to failure, even on roads where track men are most diligent.

Some of the early bonds made of flat copper strips, to which reference has been made, were not only bolted to the rails but were also soldered. As soon as it had been shown that the two dissimilar metals could be thoroughly united by solder interest in a soldered terminal bond developed and during the past three years has become very pronounced as the advantages of this form of bond have become apparent. Experiments and tests have been made in the laboratory and in the field, for although many advantages of the bond were obvious there yet remained details

of design, construction and application to be worked out to insure its complete success under the practical conditions of service.

Soldered bonds can be made relatively very short, a decided advantage where there conductivity is less than that of the rails themselves, and always an advantage in the matter of initial cost. They can be applied in any position where other forms of bonds can be applied and in some positions where it is impossible to install other forms, notably on the side of the ball of the rail, a very economical advantage in construction and maintenance. They can be made of any capacity desired and with contact area ample to prevent heating at the terminals, so that if rightly installed carrying capacity equivalent to that of the body portion of the bond is insured, and that is the true function of a rail bond.

In the matter of design it is essential that the several types be adapted to the size and style of rail and joint plate to be used, to provide ample terminal contact area and a body sufficiently pliable to meet extreme requirements.

In the manufacture of any bond the use of excessive heat, more than 500 degrees fahrenheit, should be avoided and on soldered bonds a flux and alloy should be used which will insure perfect homogenity at the terminals and which will not lend themselves to electrolytic action or corrosion.

It has required years of service in the field to achieve the perfected soldered bond. Careful experiments and tests were necessary to determine what materials and processes were best suited for construction and installation to insure a permanent bond permanently attached to the rail.

It has been shown that a visual examination is not sufficient proof of a good soldered joint. At least one manufacturer has devised a simple and effective method of testing by applying a direct shearing stress on each terminal. This test is a predetermined number of pounds strain per square inch of contact area equal to at least 60 per cent. of that required to rupture the soldered connection. Failure of soldered bonds in certain specific cases has been attributed to the difference in the ratio of expansion and contraction of the two metals or to crystallization, but it can safely be said that not a single bond has failed from either of these causes where the soldering was properly done.

The adoption of single-phase alternating current will tend to limit the capacity of bonds required, but nowhere is the importance of having bonds and having good bonds emphasized more than on roads operated by alternating current. Where alternating current is used electrolytic action will be practically nil, but it is nevertheless necessary to have a thorough contact between the bond and the rail to avoid loose joints, corrosion and loss of current.

There is bound to be a greater interest in the subject of rail bonds as engineers and managers come to appreciate their full importance and the direct effect they have on current consumption and operating expenses. The relation of rail bonds to the coal pile is very direct and intimate. The first cost of bonds and their installation is, of course, a question of importance but should be secondary to that of efficiency.—*By Edwin M. Hamlin.*

SAN FRANCISCO GAS AND ELECTRIC COMPANY'S GREAT FIRE.

ONE of the most disastrous fires that San Francisco has ever had occurred on the morning of February 22nd, when in a few short hours one of the most complete and expensive electric power plants in the United States was reduced to junk and ashes. This was the burning of Station C of the San Francisco Gas and Electric Company. After a stubborn fight by the department the fire was confined to the power plant and annex.

There has been many theories advanced by engineers as to the cause of the fire and also the explosion. It may be definitely stated, however, that no explosion took place in the dynamos, as has been reported, but sometime after the fire started the smoke and gas that accumulated in the tunnel that carries the conduit became ignited and an explosion occurred. This gas in the tunnel was caused from the burning insullation around the coils. It is entirely too soon to determine the true cause of the fire.

One of the most phenomenal feats of electrical engineering has been performed by Chief Electrician Samuel Napthaly, and his able corps of assistants, in bringing order out of chaos in so short a time. It was just seventy-two hours from the time the first alarm was given until the entire district, one of the largest in San Francisco from the view point of consumption, was again in normal condition, connections having been made with outside stations supplying direct current. This involved the laying in underground districts of thirty pair of cables.

The work of reconstruction is being rapidly carried on and fortunately the annex, in which a number of new motor-generator sets had just been placed, was practically uninjured. The financial loss was very heavy.

In the April number of THE JOURNAL we will endeavor to give illustrations of the burnt district and also an article on the cause of the fire.

PERSONAL

Willard W. Low, D. Hemingray, A. N. Palmer.

It was midnight when the bells rang in the arrival of the only famous "Billy" Low, president of the Electric Appliance Company, of Chicago and San Francisco.

"Billy" accompanied by "Dan" Hemingray of the World's famous Hemingray Company, manufacturers of the Hemingray Insulators, arrived on the midnight train from Chicago.

WILLARD W. (BILLY) LOW.

Mr. Low is making his annual visit to the Coast in the interests of the company he represents, and the trade in general hopes that he will find a few leisure moments in which we might acquaint him with some of our "latest born."

Since "Billy's" last trip to the Coast there are many new faces in the field and many new companies organized. As it is essential that everyone in the electrical business should know "Billy" and he is just as anxious to know them, it is therefore the humble duty of the boys of the Coast, and especially of 'Frisco, to see that Mr. Low is carefully looked after. No one from the Pacific Coast has ever gone beyond the Rockies without meeting this same "Billy" Low; and history does not relate the time when any of our boys has ever known to want for anything when on any of their sojourns to his town.

Mr. Low and Mr. Hemingray will be in San Francisco for the next ten days, as will also Mr. A. N. (Al) Palmer, general sales manager of the Phillips Insulated Wire Co., whose wide experience in things electrical and otherwise has made him famous, also no one that we know of is better prepared or is any more willing to offer to the trade his knowledge of the famous "O.K." weather-proof and "Parac" rubber-covered wires than this same "Al" Palmer.

We have also in our midst the famous McDowell, who, for the past fourteen years, has been travelling to the Coast in the interests of the Manhattan Electrical Supply Company, and whose smiling face is just as familiar on Cortland Street, New York, as that of "Billy" Low at any of our annual conventions.

The trade in general, and THE JOURNAL in particular, extends to our distinguished guests a most cordial welcome, and we trust that next year will see them with us again.

Mr. E. L. Wayman, assistant manager of the California Electrical Works, is away on a business trip for his house.

Mr. L. E. Sperry, president and general manager of the California Electric Works, has just returned from an extended eastern trip.

Mr. E. M. Scribner, general manager supplies sales of the Los Angeles offices of the California Electrical Company, is in the city on a short visit.

Graphite—The JOURNAL has to acknowledge the receipt of the Febrnary issue of Graphite published by the Joseph Dixon Crucible Company in Jersey City, N. J.

Gates Rock and Ore Breakers—The Allis-Chalmers Company have issued an attractive and well illustrated brochure which deals with the important subject of the Gates gyratory form of breakers. In other words this booklet contains complete instructions of setting and operating style "D" Gates rock and ore breakers and should be kept for reference. It is printed on good stout durable paper and the type is bold and clear. It is a credit to the firm which has its name on the imprint.

The McDougall Roasting Furnaces—In a recent bulletin of the Allis-Chalmers Company, No. 1409, is an account of the McDougall roasting furnace which can be thus briefly described: The McDougall roasting furnace of the self-contained type, having five or more hearths superimposed upon each other, and contains the largest amount of hearth area, in proportion to floor space occupied, of any roasting furnace on the market. The general plan of the furnace consists of a cylindrical shell made of tank steel plate which contains and supports the various hearths, shaft, rakes, feeder, etc. This shell, together with the cast iron plates which form the bottom of the furnace, are in the standard type of furnace, supported some ten or twelve feet above the ground level by structural steel beams and columns; the latter also carry the driving machinery.

Electricity and Home—THE JOURNAL takes sincere pleasure in calling to the attention of the sterner sex who are blessed with help meets to a little pamphlet which is issued by the General Electric Company, of Schnectady, N. Y., and it prefaces its remarks by the statement that no matter how important an invention or series of inventions, yet it or they fail if not bringing some amelioration to the home, *i. e.* the wife. While our past inventors have labored hard to better the conditions of the workmen, some of them have not forgotten the home, and we have the sewing machine and the humble, though useful, carpet sweeper. The gas man with an eye to the bill has invented a gas stove which, while freeing the house from coal and coal dust, has plunged many a house in dire distress by "the inflation of the weekly bills." Now the General Electric Company intends even to be a greater boom to the tired housewife. It has invented a number of household electric devices which can be used with safety and with comfort. For instance, the lady can now cook and heat with electricity. In former days the cost of using electricity was almost prohibitive, but with the new devices of this company it is cheap. This is what the little pamphlet says in brief and it is really worth considering.

Coal produces heat with ash, carbon dioxide, and carbon monoxide (coal gas.)

Oil produces heat with soot, smell and carbon dioxide.

Gas produces heat with carbon dioxide.

Electricity produces heat without ash, soot, smell, flame or gas of any kind.

Now it would appear that the day of ideal housekeeping has arrived.

Arc Lighting Apparatus—THE JOURNAL has to acknowledge the receipt of three interesting bulletins from the General Electric Company, of Schnectady, N. Y. It need hardly be said that these bulletins represent the best of the printers' art and are invaluable to those interested in electrical work. Bulletin 4428 deals with arc lighting apparatus. The paper deals with the electric lighting industry and goes on to show the uses of arc lighting apparatus. This is operated on both alternating and direct current circuits of both high and low tension for outdoor and also indoor service. The lamp can be supplied with current from power or lighting mains and can be arranged in series or in multiple. It is impossible to enumerate in short space of this paper the many purposes of the arc lamp, but it can safely be said they are numberless.

Bulletin No. 4429 which is issued by the same company, deals with the subject of General Electric switchboard instruments. Type R voltmeters and ammeters have been developed to meet the demand for a compact, accurate and moderate priced line of instruments for use on alternating and direct current switchboards.

Bulletin 4430 is on variable speed motors. This is an interesting subject and treats on the application of electric motors to machine tools. The purpose of this publication is to show how, by the electric drive, these economies are obtained and to review briefly the growth of this new application.

At Home and Abroad—"Allis-Chalmers Engines—At Home and Abroad," is the title of a rather unique bulletin about to be issued by the Milwaukee company—unique from the fact that it contains sixty-eight pages without a vestige of reading matter except brief descriptions underneath the cuts and a list of the company's products at the end.

The title page illustration, represents four huge engines, capable of furnishing 35,000 horsepower installed in the power house of the Twin City Rapid Transit Company, Minneapolis. Other plants shown include those of the New York Interborough Rapid Transit Company, "Subway" and "Manhattan" Stations, New York City Railway Company, Brooklyn Rapid Transit Company, Chicago Metropolitan West Side Elevated Railway Company, Chicago Union Traction Company, Central London, Eng. (Underground) Railway, London United Tramways, Ltd., Dublin, Ireland, Tramways; Cincinnati Gas and Electric Company, St. Louis Union Electric Light and Power Company, St. Louis and Suburban Street Railway Company, Glasgow United Tramways, Detroit United Railway, Bristol, Eng. United Tramways; Kansas City Metropolitan Street Railway, Kansas City, Kan.; Consolidated Electric Light and Power Company, Middlesboro, Eng., Power Station; Cleveland Electric Railway Company; Toledo Railway and Light Company, Barcelona, Spain, Tramway Company, Ltd.; Grand Rapids Electric Railway Company, Isle of Thanet, Eng., Tramways; Sidney, New South Wales, Government Tramways; Buenos Ayres, Argentina, Compania Alemana Transatlantica de Electricidad; Havana, Cuba, Electric Railway Company; Louisville Railway Company, and other well known companies.

Pumping engines, a number of which hold world's records for economy and efficiency in their respective fields of operation, are shown installed in the plants of the Boston Metropolitan Water and Sewerage Board, Chestnut Hill, Ward Street, Charleston and Deer Island stations, Chicago Water Works, Thirty-ninth Street and Chicago Avenue stations, Pittsburg Water Works, Brilliant station, St. Louis Water Works, Baden station and large industrial plants.

Blowing engines are represented by impressive lines at furnaces of the Carnegie Steel Company, and American Steel and

Wire Company, air compressors by machines in operation for the Anaconda Copper Mining Company, and Atlas Portland Cement Company and hoisting engines by numerous mining installations, prominent among which is that of the famous LeRoi mine at Rossland, B. C.

BOOK REVIEW.

Scientific Literature—The D. Van Nostrand Company's monthly record of Scientific Literature has been received at this office. It contains a complete catalogue of the new publications.

Yale Scientific Monthly—The JOURNAL acknowledges the receipt of the Yale Scientific Monthly and especially wishes to call attention to the initial paper, "The Part of Pumping Machinery" by W. C. McLeod.

Gas Power—THE JOURNAL is in receipt of two pamphlets which contain articles reprinted from Cassier's Magazine upon gas power. J. R. Bibbins is the author and the subject on which he treats is gas power for high pressure city fire devices and uses the Philadelphia system as an example to prove the truth of his remarks. He has also another pamphlet which deals with gas power in electric railway work which is exceedingly interesting.

The Question Box—The National Electric Light Association was at its twenty-eighth convention presented with the fourth issue of the Question Box which at the first blush may be said to be an eminently useful book for all those interested in electrical work. The editor, Homer E. Niesz, deserves great credit for the able manner in which he has handled the subject. There are hundreds of questions propounded and the answers are written so plainly that the veriest tyro will be able to understand what is meant. The Question Box can be highiy recommended to ail electricians.

Mineral Resources—David T. Day, chief of division of mining and mineral resources has issued through the Government printing press an extremely interesting volume regarding the mineral resources of our country. The book is of extreme value as the information contained within its pages is absolutely correct and not influenced by interested parties. The figures show a continuation of the activity in the mineral resources of the United States, though the value of the output for 1904 was about 9 per cent. less than for 1903.

In 1904, for the fifth time, the total value of our mineral pro duction exceeded the sum of $1,000,000,000. The exact figures for 1904 were $1,289,047,146 as compared with $1,419,280,617, in 1903, with $1,260,501,898 in 1902, with $1,086,550,871 in 1901 and with $1,063,678,053 in 1900; a loss in 1904 from 1903 of $130,233,471, or 9.18 per cent. As in previous years iron and coal are the most important of our mineral products. The value of iron in 1904 was $233,025,000; the value of the coal $444,816,288. The loss of $130,233,471 in the total value of our mineral products is due to losses in both metallic and nonmetallic products, the metallic products showing a decrease from $626,318,008 in 1903 to $541,466,796 in 1904, a loss of $82,851,212 and the nonmetallic products showing a decrease from $793,962,609 in 1905 to $747,180,350 in 1904, a loss of $46,702,259.

$600,000 FOR IMPROVEMENTS TO SEATTLE MUNICIPAL PLANT.

THE Seattle Common Council will submit the following ordinance to a vote of the people of Seattle at their election on March 6, 1906:

Whereas, The City of Seattle owns and controls a plant or system for furnishing light and power, or both, for corporate or individual uses, or both uses, which said plant, was constructed and acquired pursuant to the provisions of ordinance No. 7707; and

Whereas, It is advisable that said plant and system be further enlarged, and the benefits of said plant or system be further extended throughout the City of Seattle by a distributing system for the general furnishing of light, heat and power among the inhabitants of said city; now, therefore,

Be it ordained by the City of Seattle as follows:

Section 1. That the system or plant, hereinafter in this section described, be and the same is hereby specified and adopted as a system or plan for further enlarging the plant and extending the distribution of electric energy for lighting, heating and power purposes for the service of the inhabitants of the City of Seattle, to-wit: That there be added to the apparatus now installed at the generating plant an additional unit of at least equal in size to the units there in service, together with such necessary transformers, switchboards and other appurtenances at the generating plant, and at the substation, and an additional transmission line from the generating plant to the transforming station, and such other necessary connecting wires as shall make the same available, and the extension in the City of Seattle, by both overhead construction, where necessary, and by underground conduits, cables and wires, within the business sections of said city, and by pole lines elsewhere; and by such additions to the present city plant as may be necessary for the distribution of electric energy and the delivery of the same to the inhabitants of said city for individual or corporate use, or both, together with all the appurtenances necessary for the service of said inhabitants with light, heat and power, as the same may be demanded, and within the estimate of cost hereinafter declared.

Section 2. That the estimated cost of the additional plan or system hereinbefore in Section One specified and adopted, is hereby declared, as near as may be, to be the sum of six hundred thousand dollars ($600,000.00.)

Passed the City Council the 29th day of January, 1906, and signed by me in open session in authentication of its passage this 29th day of January, 1906. H. C. GILL.

President of the City Council.

Approved by me this 31st day of January, 1906.

R. A. BALLINGER, Mayor.

Filed by me this 31st day of January, 1906.

Attest: (Seal) JNO. RIPLINGER, City Comptroller and ex-officio City Clerk.

Published February 1, 1906.

CHICAGO ELECTRICAL SHOW.

THE "Electrical Show" held at the Coliseum Building, Chicago, January 15-27, proved to be a great success both from the popular and technical standpoints. Crowds thronged the place every afternoon and evening, and in the number were engineers as well as others interested in electrical apparatus. The exhibits included appliances and machinery of every description, from electric lamps, fans, stoves, clocks, batteries, X-ray apparatus and "Novelties" to motors, dynamos, engines, and turbine parts.

Among the manufacturers of power machinery and auxiliary electrical apparatus, was the Allis-Chalmers Company of Milwaukee. One of their twenty-five horsepower Bullock type "N" motors, receiving direct current, was used to drive a sixty-kilowatt, belted Bullock alternator, which in turn, generated alternating current for a line of Bullock induction motors ranging in capacity from two horsepower to thirty horsepower. A direct current Bullock type "B" motor was run separately.

Engineers, were attracted by the ring with blading from a 1500-kilowatt steam turbine, which was placed on a frame work in one corner of the booth. Beside it was a description of the unit recently installed for the Utica (New York) Gas and Electric Company; and the details of construction, particularly the formation and method of securing the blading, were much discussed. There was also shown a section of blading from a 5500-kilowatt turbine, as built at the West Allis shops of the Allis-Chalmers Company, together with samples of smaller blading.

The booth was lighted by a dazzling red, white and blue electric sign, from which hung clusters of incandescent lamps. A desk, settee and chairs in Mission style, with posts, railings and floor covering to match, and also a set of Oriental rugs, completed the furnishing of the booth.

INDUSTRIAL

SHIPMENT OF HEAVY PIECES OF GENERAL ELECTRIC MACHINERY.

THE development of electrical manufactures, leading as it has to the design of generating units of constantly increasing capacities, has brought up some difficult problems in the transportation of large and heavy pieces of machinery. The largest electrical manufacturer in the world is naturally the one to encounter the most interesting experience resulting from this growth. A factory whose incoming freight for one year, including raw material for its manufacturing operations, its fuel and building materials, amounts to more than 350,000 tons, and whose outgoing freight for the same period exceeds 130,000 tons, must handle all kinds, sizes and shapes, from the annual incoming 133 miles of freight cars, and must exercise more than ordinary care and foresight in preparing machinery for shipment in the fifty-mile outgoing freight train.

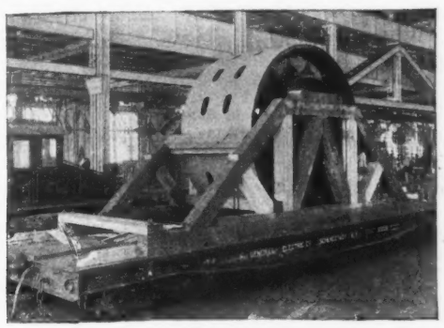


FIGURE 1. ARMATURE OF THE FIRST 5000 K. W. CURTIS STEAM TURBINE-GENERATOR, BUILT AT THE SCHNECTADY WORKS OF THE GENERAL ELECTRIC COMPANY, IN PLACE ON ITS CAR READY TO BE HOUSED FOR SHIPMENT TO THE CHICAGO EDISON CO.

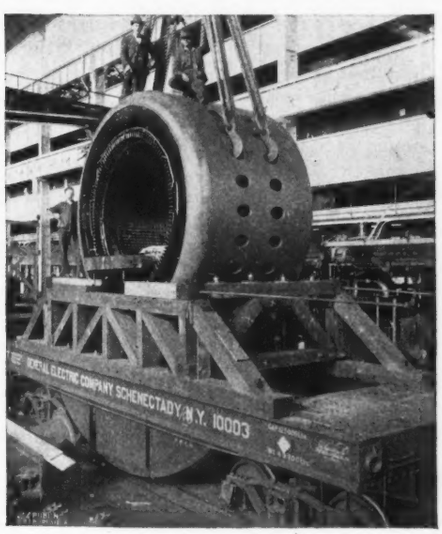


FIGURE 2. SPECIAL CAR GE-10003, FOR SHIPMENT OF LARGE TURBINE GENERATOR ARMATURES, SHOWING A 5000 K. W. ARMATURE BEING LOWERED INTO PLACE

It is interesting to note some of the special shipping arrangements that have been developed to handle the mammoth single pieces of electrical machinery now manufactured by the General Electric Company at Schnectady, N.Y.

The armatures of slow-speed revolving field engine driven generators are necessarily of large dimensions and heavy weight, but such parts are always built so that they may be shipped disassembled, and therefore do not present any extraordinary difficulties in transportation. The largest engine driven generators installed in New York City—the 5000-kilowatt Interbourough Rapid Transit Company's machine—have armatures which are 42 feet high, 44 feet long and 9 feet wide at the base and weigh 558,000 pounds, but these were built in seven sections and assembled at the place of installation.

On the other hand, it is quite advantageous to build an entire armature in one piece ready to be installed, thereby saving a large amount of work at the factory and avoiding the necessity of sending expert armature winders to the place of installation. The method of constructing the armature in one piece is adopted by the General Electric Company in the manufacture of the Curtis steam turbine generator in all sizes, the largest of which at the present time is capable of generating 12,000 kilowatts, though normalty rated at 8000 kilowatts. The armature of one of these 8000 kilowatt turbine generators is naturally a heavy piece to ship, notwithstanding the fact that the weight efficiency of the turbine generator is high compared to that of an engine-driven generator of equal capacity, on account of the comparatively high speed permitted by the turbine drive.

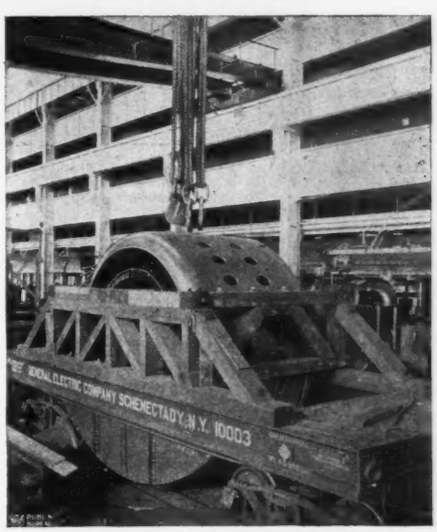


FIGURE 3. SPECIAL CAR GE-10003, WITH 5000 K. W. TURBINE GENERATOR LOWERED INTO PLACE ON ITS CRADLE, READY TO BE HOUSED FOR SHIPMENT

The armature of the first 5000-kilowatt Curtis turbine generator (built for the Chicago Edison Company's Fisk Street Station) weighed 111,000 pounds, without the top bracket. It was found that no railroad in the country had available a car of sufficient capacity to transport the armature, while even the heaviest General Electric Company's special freight car was rated about six tons too low for the purpose under master car builders' rules.

The armature was, however, loaded on its car, and after careful examination by inspectors of the New York Central Railroad Company the shipment was accepted for transportation by that road and was ordered forward "special," *i. e.*, with a special locomotive and picked crew, and only a sufficient number of cars to ballast the train.

Figure 1 shows the armature in place on its car, ready for housing, and figure 4 illustrates the housed armature and its extreme height compared with the ordinary box car. Under these conditions the armature was moved from Schnectady to Chicago in safety. The armature shown on this car is the heaviest single piece of freight ever shipped by the General Electric Company.

Orders received by the General Electric Company for four 5000-kilowatt and two 8000-kilowatt turbine-generators for the New York Edison Company's Waterside Station and eight 5000-kilowatt turbine-generators for the Port Morris and Yonkers Stations of the New York Central Railroad again brought up the question of transportation. The armature of each of the 5000-kilowatt machines consists of a single piece about twelve feet in diameter and eight feet wide, weighing about 122,000 pounds without the bearing jacket. It was found that by using the General Electric Company's new flat cars of special low type and 135,000 pounds capacity, the armature could be shipped as far as Port Morris, but only by a roundabout route, as the height of the bridges and the width of the roadbed between Schnectady and Yonkers would not admit of transporting the armatures direct by the Hudson River Division of the New York Central. In order to forward the shipments from Port Morris on, it was proposed to lighter them from Port Morris to Yonkers and New York.

The inconvenience of this lighterage and its excessive cost led the General Electric Company to seek further means of transporting the armature over the direct all-rail route. Accordingly a new flat car, specially designed to transport heavy machinery within standard railroad clearances, was purchased at a cost about equal to the literage charge on the shipment of one armature only.

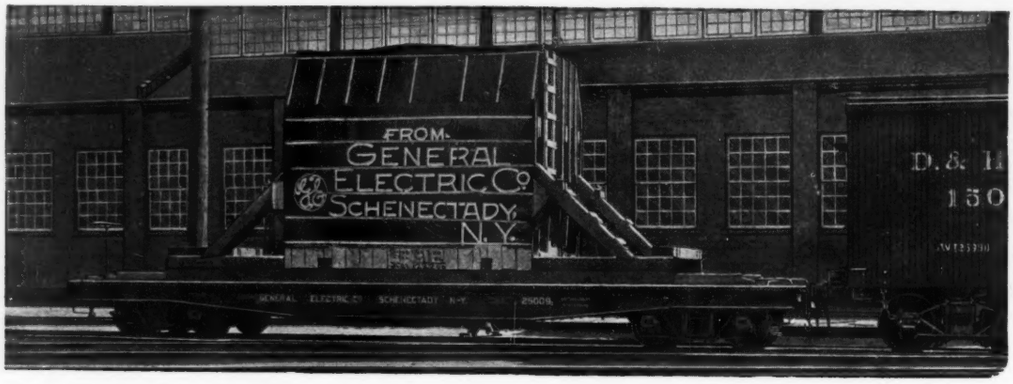


FIGURE 4. ARMATURE OF FIRST 5000 K. W. CURTIS TURBINE GENERATOR, BUILT AT THE SCHNECTADY WORKS OF THE GENERAL ELECTRIC COMPANY HOUSED ON CAR READY FOR SHIPMENT (SHOWING COMPARATIVE HEIGHT WITH ORDINARY BOX CAR)

The accompanying illustrations, figures 1 and 2, show one of the 5000-kilowatt armatures for the New York Edison Company being loaded on this new car (GE–10003), and in its final position on the car ready to be housed for shipment, respectively. The car has a carrying capacity of 125,000 pounds, with privilege of 10 per cent. overload. It is thirty-two feet long and five feet six inches high above the rails, and has a rectangular well fifteen feet long and eight feet wide, which allows a shipment the size of an 8000-kilowatt armature to be supported with its bottom about six inches above the tops of the rails. The well is enclosed in sheet iron, to protect the load from dirt, and the load is slung on four heavy iron straps, which are secured in a timber truss bolted to the deck frame of the car.

The General Electric Company now has fifteen special freight cars, of 1,630,000 pounds aggregate capacity, including three cars built with a well as described above. It is worthy of note that the transportation department details a man to keep in constant touch with all of these cars, by telegraph communication with all of the roads over which shipments are made. Notwithstandimg this special organization for the return of "empties," the congestion of the railroads is so great that deliveries of several large machines have been delayed for lack of cars to ship them.

Three centrifugal pumps, each having a capacity of ten million gallons daily, for the Massapegna Pumping Station, Borough of Brooklyn Water Works, have been recently contracted for with the Allis-Chalmers, Company, Milwaukee, Wis. The contracts were let by Michael J. Dady, general contractor, Brooklyn, N. Y. The pumps will be driven by vertical cross compound engines.

HYDRO-ELECTRIC INSTALLATION.

AN extreamely interesting problem in the utilization of a water power with a small fall and large variation of head for the production of electric current has been skillfully solved in the design of two 900 horsepower turbines which the Allis-Chalmers Company has built and is now installing at Sewalls Falls, N. H., for the Concord Electric Company. The first installation will consist of two complete hydro-electric units, each composed of a triplex turbine water wheel and a direct connected alternating current "Bullock" generator, a motor-driven exciter set, turbine governors and electrical synchronizers.

As the current is to be used chiefly for lighting purposes, and possibly in connection with other sources of power generation, it is necessary to have the speed of revolution for the wheels and generators constant, even though the amount of developed power might differ under different heads.

Ordinarily the stream produces a fall which gives a net working head of sixteen feet. In times of flood, however, the water backs up in the lower channel so as to reduce the working head to twelve feet.

To secure the desired results the Allis-Chalmers Company has designed the turbines, each with three sets of runners and gates complete, the three sets being arranged one above the other on a vertical shaft. The three sets of runners are all connected to the tail race by means of draft tubes, so as to derive the full energy of the water, due to its actual head, from each of the runners, no matter what its relative or actual position may be upon the shaft. The lower runner of each wheel has a draft tube by itself, while a single tube of larger dimensions carries off the discharge water from the two upper runners. The turbines are of the Francis central discharge type. The three runners on each wheel are each of equal size, form and capacity; but they do not all discharge in the same direction. The lower one discharges downward into an individual concrete draft tube. The upper runner discharges downward and the middle one upward, both into a separate concrete draft tube which joins the lower one at the bottom of the tail race. The reactions from these two runners practically balance one another, while the reaction from the discharge of the lower runner, being upward, tends to lift a portion of the load on the turbine shaft. This effect is considered negligable in the turbine design, but provision is made for using the pressure due to the head of water to actually carry a considerable part of the weight of the turbines and the generators at all times. This is done by admitting the water of the flume into a space directly under the second runner of each turbine, where it exerts its pressure upward against a circular plate which forms a revolving piston. The water will carry about one-third the weight of the rotating parts. The other two-thirds is carried by a thurst bearin supported by the castings of the turbine.

The bearing is made of generous proportions so as to operate safely without oil under pressure for lubrication. The lubrication is, in fact, provided for in an ingenious manner which appeals to

one as being as effective as it is simple. A well is formed outside the bearing rings and this is filled to a suitable height with oil. The oil flows to the inner part of the bearing through suitable holes, passes through the bearing, guided by proper grooves, and is returned through holes to the well. The circulating action is continuous as long as the wheel is in action and it is automatic. At two points below the thrust bearing the shaft is kept in line by steady bearings carried by portions of the wheel casings. The wheel casings are self-supporting besides carrying the weight of the rotating parts, one section being built on top of the other, and each provided with four stout columns to carry the weight. The casings are steadied and held against vibrations and side strains by having certain parts carried over to the walls of the draft tubes. These walls are of concrete and the draft tubes are also of concrete, the whole walls and tubes being built as one solid structure of monolithic character.

The wheel cases are all divided so as to permit of dismantling without disturbing the shaft or generator parts, and are put together with machined and ground joints.

The shaft itself is in two parts coupled together just below the generator. The runnors are of non-corrosive bronze, each cast in one piece. They are fifty-five inches in diameter. Surrounding each runner are the gates which admit the water to it and control its speed. Outside the gates of each runner, and reaching all around it so as to admit water to all parts of the periphery of the wheel at once, is a space ample for that purpose.

The gates are composed of movable guides vanes and so constructed that when open they admit a full head of water with but little interference, and, when closed, totally exclude the water. They are all connected by links to a common gate ring and arranged so that a minimum of power is required to operate them.

The operation is through two countershafts standing parallel to the main shaft. These are each provided with a crank at each set of gates, and the cranks are connected to the gate rings by links. One-eighth of a turn of the shaft completely closes the gates. An energy of not more than 12,000 foot-pounds is all that is required for this operation.

This power is supplied by the governor for each wheel.

The governors are placed on the generator floor beside the generators. They are of the Allis-Chalmers Standard type of self-contained oil pressure hydraulic governor. The design of this governor is such that no changes in arrangement will need to be made should three or more units be added to the plant. Such additions are not unlikely after two or three years. The permissible variations in speed under sudden variations of load are shown in the following table:

Variation of load per cent.	Permissible variations in speed.
25 per cent.	Not over 2 per cent. in 1.5 seconds
50 per cent.	Not over 4 per cent. in 2 seconds
75 per cent.	Not over 6 per cent. in 2.5 seconds
100 per cent	Not over 8 per cent. in 3 seconds

Each governor is driven from a horizontal shaft running under the floor, which takes its motion from the main shaft of the turbine through the medium of a bevel gear.

The bevel wheel on the main shaft is formed by attaching a toothed rim to the outside of the collar of the coupling which joins the two portions of the shaft. A "Morse" silent chain gear connects the governor to the horizontal shaft and drives the governor. The chain is cased in.

The speed is regulated by sensitive fly balls working against knife edges and the actual control of the gates is accomplished through the agency of oil under pressure operating through the medium of a piston controlled by a pilot valve. These regulators are so constructed as to eliminate "hunting" and insure very close regulations. The governors are so arranged that they are under control electrically from the switchboard, and synchronizers and motors for controlling the governors form a part of the outfit of the station. This makes it possible to increase or diminish the speed of either of the wheels at pleasure or to shut down units from the switchboard in case of an emergency.

The wheels will each produce 900 horsepower with a sixteen-foot head on a consumption of 620 cubic feet of water per second, or 625 horsepower at twelve-foot head with a flow of 650 cubic feet per second. Working at full gate they are expected to economize 78 per cent. of the power of the water, or more, and to give 80 per cent. return at three-fourths gate. At half-gate they are expected to economize 75 per cent. of the power of the water. They operate at 100 revolutions per minute.

Standing directly over the turbines with their stator parts supported on the generator room floor are the two generators, one for each turbine. The rotor shafts are direct coupled to the shafts of the turbines and form the upper parts of the turbine shafts. the weight of the rotors is carried by the thrust bearings of the turbines; but they have a steady bearing above the coupling to keep them in line.

The generators are of the Allis Chalmers "Bullock" vertical water wheel type, with upper guide bearing supported in a housing bolted to the stator. The stator or armature rests on a substantial cast iron ring supported by the foundation. The revolving field consists of a cast steel spider securely keyed to the vertical shaft and provide with dove-tail grooves in its rim for holding the laminated pole pieces which are secured in place by tapored steel keys. The field coils are wound with copper strip bent on edge.

Each generator can deliver 500 kilowatts at 2600 volts, three-phase, sixty-cycles, 111 amperes per line. The speed is 100 revolutions per minute, the revolving fields having seventy-two poles. The fields are wound for separate excitation at 129 volts and the generators have an efficiency of 94 per cent. at full load, 93 per cent. at three quarters load, and 91 per cent. at half load. They are capable of meeting the usual high guarantee of the Allis-Chalmers Company regarding heating and will stand a 100 per cent. momentary overload without injury.

The armatures have a three-phase winding of heavily insulated coils capable of standing a 5000-volt puncture test between coils and frame. The field insulation is tested with 1500 volts applied between the coils and field cores or spider. The supporting yoke for the armature core is of open construction and since the core itself is provided with numerous ducts or air channels, the ventilation is very thorough.

For exciting the alternators, a motor-generator set consisting of a seventy-five horsepower induction motor coupled to a forty-five-kilowatt direct current generator is provided. The induction motor is wound for 2600 volts, three-phase, sixty cycles, and the generator for 120 volts; the full load speed is approximately 680 revolutions per minute. Both machines are mounted on a common bed plate and the set has three bearings two of which are carried in end housings bolted to the stator yoke of the induction motor.

HOME TELEPHONE COMPANY, OAKLAND.

Brown, Spear, Sloane Company report having sold Stromber-Carlson ariel and underground cables which will form the greater part of the cable installation being made by the Home Telephone Company in Oakland, Cal. The Stromberg-Carlson Telephone Manufacturing Company are now carrying with Brown, Spear, Sloane Company in San Francisco, Los Angeles and Seattle considerable stocks of Stromberg material embracing complete switchboards, telephones and inter-communicating systems. The Safety Insulated Wire and Cable Company are also appreciating the importance of carrying Pacific Coast stocks, as they have recently placed with Brown, Spear, Sloane Company in Los Angeles, as well as San Francisco, a complete stock of safety seemless rubber covered wire.

The American Car and Foundry Company has recently concluded the purchase of an addition to the present power plant at its Huntington, W. Va., works, from the Allis-Chalmers Company of Milwaukee.

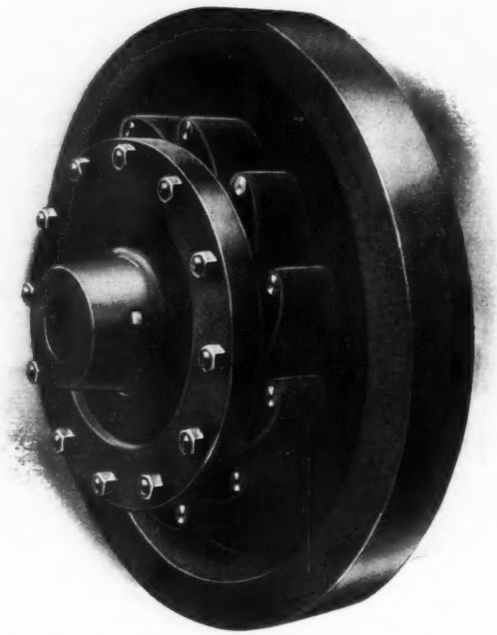
H. G. AYLSWORTH.

THE host of friends of Mr. Aylsworth will be pleased to learn of his starting in business for himself, having taken over the Californian interests of the Kilbourne & Clark Company, with whom he has been associated for the past three years as Pacific Coast manager. Mr. Aylsworth will occupy the entire third floor of 569 Mission Street, where he will carry a complete stock of telephone and electrical supplies, also bridging telephones and switchboards, intercommunicating and hotel telephones and telephone specialties. Mr. Aylsworth will have the Pacific Coast agency for the following well known concerns:

Chicago Telephone and Supply Company, Elkhart, Ind.; Electric Goods Manufacturing Company, (formerly Electric Gas Lighting Company), Boston, manufacturers of house telephones and annunciators; Simplex Instrument Company, Newark, N. J., makers of both volt and anmeters; American Arc Light Company, Kalamazoo, Mich.; Schwartz Electric Company, Adrian, Mich., manufacturers of electric bells; Francis Keil & Son, New York, full line of bells and electric hardware; General Storage Battery Company, New York, manufacturers of Bijur batteries. Mr. Aylsworth with his own strong connections and backed by such prominent Eastern houses cannot fail to score an immediate and permanent success.

PELTON SPECIALTIES.

THE Pelton Water Wheel Company does not confine its manufacture to Pelton wheels alone. A recent order from the Santa Cruz Portland Cement Company is for twenty pair of flexible leather link couplings of design similar to the illustration herewith. These couplings are to be used for transmitting power from electric motors to the shaft of cement grinders, and



carry from 250 to 400 horsepower. The special feature of this coupling is the flexibility obtained by using leather links. There is thus gained sufficient play to admit of the shafts being considably out of alignment, due to a settling of foundations, without interference with the carrying capacity, and by its use is obviated the necessity of a positive and continuous sole-plate connection, usual in such cases, between the driving and driven machinery. These couplings are made of various sizes and to accommodate any speed and carrying capacity.

As another adjunct the Pelton Water Wheel Company has secured the agency for a patented lapweld pipe manufactured in Germany. This pipe is made by a continuous weld gas process, insuring a perfectly homogeneous weld, and enabling the pipe to be turned out in any length or diameter. Notwithstanding the fact that this pipe is imported and carries a heavy duty, it is sold in competition with that made in this country, and some large installations have already been made.

Among recent orders for Pelton wheels may be mentioned the plant of the Fremont Power Company, consisting of two units each of 1100 horsepower, operating under a head of 1090 feet, the wheels being of the single overhung type.

The Northwest Light and Water Company has placed an order for a 1500 horsepower Pelton wheel under a head of 150 feet.

A complete pipe line for the Eel River Power and Irrigation Company has been furnished by the Pelton Company, and consists of approximately 1600 feet of sheet steel riveted pipe, varying from sixty-two inches to fifty-eight inches diameter and from three-sixteenth-inch to nine-sixteenth-inch in thickness. This pipe line is made at the works of the Pelton Company, in Harrisburg, Pa., and the contract covers the pipe completely installed in the trench.

The demand for water wheels in foreign countries is steadily increasing, a large number of orders from Central and South America having been received this month.

NOTICE FOR BIDS—MUNICIPAL BONDS.

$75,000.00

"Palo Alto Improvement Bonds," Town of Palo Alto, County of Santa Clara, and State of California

Assessed valuation of property, 1905.....$2,900,000.00
Estimated assessed valuation, 1906..... 3,000,000.00
Estimated actual value of property..... 6,000,000.00

Date of sale April 5, 1906. Hour 8 p. m. Sealed Bids

Purpose of issue, municipal improvements. (*a*) Extension water and electric lighting plant. (*b*) Extension sewer and water system. (*c*) Construction storm sewer. (*d*) Construction town hall. Amount of this issue, $75.000. All to be sold now. Denominations series, $1000. Series 2, $875. Rate of interest both series, 5 per cent., payable semi-annually. When to be dated: Both series, May 1, 1906. Payable at Town Treasury, Palo Alto. When due: The first bond of each series payable one year after date, or May 1, 1907, and one bond of each series each year thereafter, forty bonds issue in each series, numbered one to forty, series No. 1 and Series No. 2. Not optional. Authority for issue: Act of February 25, 1901, Statutes (Cal.) 1901, p. 27. Bonds payable in gold coin.

VOTE.

(*a*) For.....281 Against.....41
(*b*) For.....244 Against.....50
(*c*) For.....252 Against.....47
(*d* For.....239 Against.....72

Total vote, 330

FINANCIAL STATEMENT

Actual valuation - $6,000,000.00 Assessed - $3,000,000.00
Population, 1890, none Population, 1896, 1400
Population, 1900, 1658 Population, 1906, 6000
Total debt including this issue - - $173,000.00
Per cent. of debt on assessed value - - -.058

Said bonds will be sold to the highest responsible bidder for cash, U. S. gold coin, payable on delivery of bonds. The Trustees of the Town reserve the right to reject any and all bids. The successful bidder must on receiving notice of award deposit with the Town Treasurer a certified check, payable to the town of Palo Alto, amounting to 5 per cent. of purchase price of bonds.

I certify the above statement to be true to the best of my knowledge and belief.

Witness my hand this 15th day of February, 1906

JOHN D. BOYD,
[SEAL] Clerk of the Town of Palo Alto.

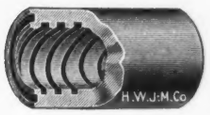
ALLIS ROLLER MILLS.

The Allis-Chalmers Company have issued bulletin 1203 which gives considerable information about the Allis noiseless belt roller mill.

A NEW DEPARTURE IN TROLLEY WHEELS.

IN the manufacture of trolley wheels such materials as arsenic, antimony, bismuth, tin, lead and spelter are frequently combined with copper, and these elements, if used only in very small quantities, seriously affect copper as a conductor of electricity, and hence shorten the life of the wheel. Alloying copper with these metals also renders the metal harder and greatly diminishes its ductility. As a result the trolley wheels cut the wire and both the wheels and the overhead construction require frequent replacement. To obviate these difficulties the H. W. Johns-Manville Company have recently placed on the market a new wheel made of absolutely pure copper, which is purified, hardened and made tough by a special treatment, known and used only by themselves. These wheels have been subjected to severe tests in actual service and have demonstrated their superiority over all other types. The salient feature of the J-M pure copper wheel that appeals to the operating railroad man is economy. The mileage is far greater than heretofore obtainable by the use of any known metal or combination of metals. They wear smooth and even and will not pit, arc or burn. In the manufacture of these wheels only the best grade of pure lake copper is used and this material is treated chemically, so as to reduce to a minimum any ingredients there may be in the copper in its crude state, and by a further chemical process exclude the action of the atmosphere, subjecting the copper to the action of carbon to remove the oxygen and render the copper solid when cast, thus increasing its malleability and durability. A still further process toughens the metal without hardening it and the result is that the wear is reduced to a minimum and the conductivity of the wheel is equal to that of the wire.

These wheels are furnished with the J-M special trolley wheel bushings, which are made from a special metal peculiarly adapted for this purpose. The tenacity of this metal is equal to mild steel, with a compressive strength of about 130,000 pounds per square inch. Its ductility and toughness are such that it will not crack when distorted by this load. It is much harder than a gold coin, and, when placed in a position where it is subjected to heat will not harden, and it is, therefore, less susceptible to wear. These bushings are packed with specially prepared packing, which is not only anti-frictional, but also a lubricant of the highest grade.



THE ABNER DOBLE COMPANY.

THE Abner Doble Company, of San Francisco, has recently taken a contract for a Doble tangential water wheel unit which will have a capacity of 13,000 horsepower, thus surpassing in power any tangential wheel now built or contracted for. The unit has been ordered by the California Gas and Electric Corporation, for installation in its noted Colgate plant, where it will form a valuable addition to that company's extensive hydro-electric system. It will be of the double wheel two-bearing type of construction, and when first installed will operate under an effective head of 660 feet, delivering 8500 horsepower. It is planned eventually to increase the pressure on one of the wheels by delivering the water through a new pipe line under an effective head of 1050 feet. This will bring the output of the unit up to 13,000 horsepower and make it the most powerful tangential hydro-electric unit in existence. The unit will operate at a speed of 300 revolutions per minute and will drive a 5500-kilowatt Westinghouse generator. It will be equipped with a Bethlehem nickle-steel hollow forged shaft, and Doble ring-oiling revolvable shell bearings, needle regulating and deflecting nozzles, ellipsoidal buckets, and centrifugal water guards.

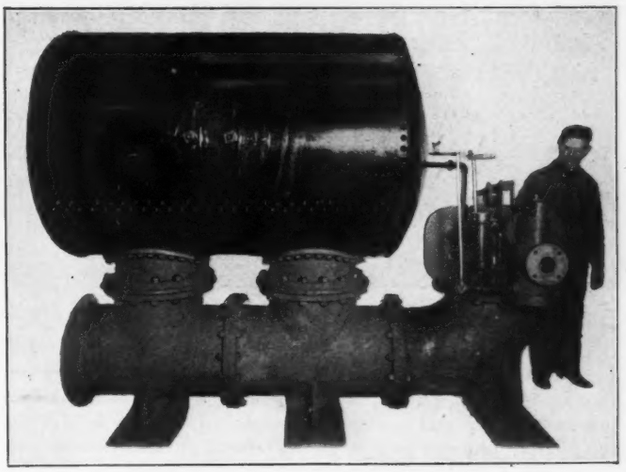
The California Gas and Electric Corporation has also ordered from the Abner Doble Company a Bethlehem nickle-steel hollow forged shaft, with two sixteen-inch Doble ring-oiling and revolvable shell bearings, for its Centerville plant. The bearings will be equipped with the latest sight-feed oil-distributing system.

THE LARGEST HYDRAULIC RAM EVER MADE.

THE ram is being used in connection with the irrigation work at Crooked River, Central Oregon, and is on the property of R. M. Morris of Trails Crossing. It has a twenty-foot drive-head and raise 250 gallons of water per minute to the height of 200 feet.

The Phillips Hydraulic Ram, it is claimed, has a water lifting capacity many times greater than any ram known, because its mechanism permits of much larger drive pipe, the Phillips being made in sizes up to forty-eight inches.

The one stumbling block to the success of hydraulic rams, from the time of their first invention in 1796, more than a century since, by Joseph Micheal de Montgolfier, has been the difficulty of designing a machine capable of withstanding the intense shocks to which they are subjected when large volumes of water are used for driving power. To overcome this obstacle many manufacturers of rams have attained fairly good results by the installation of a number of small units, but it is to the Phillips hydraulic ram alone that the credit must be given for accomplishing the same end by means of a single unit, thus making it available for hydraulic operations formerly considered impracticable.



THE LARGEST HYDRAULIC RAM EVER MADE

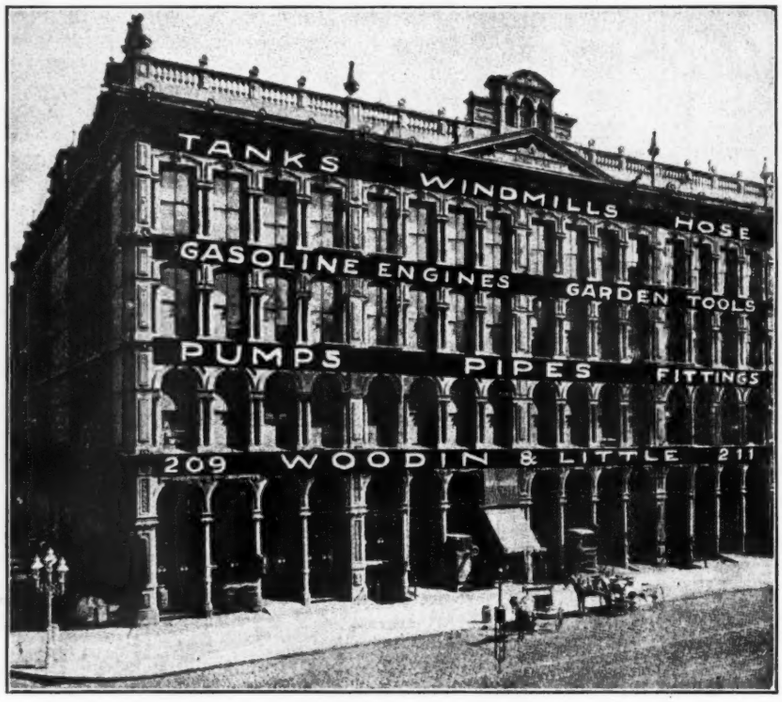
The heavy shocks imparted to the old style ram by the sudden closing of the waste valves always has been an injurious feature and has limited its use to small sizes and comparatively low heads. By a simple operating device and by a different construction of the waste valve, the Phillips ram has effectually done away with this evil. Instead of closing the waste valve, as heretofore, by the outflowing water, it is periodically raised and lowered by an independent valve, which receives its water from the main source of supply.

An arrangement of cocks permits the varying of the number of impulses within a wide range, thus closing the waste valve at the precise instant when the energy of the water is at its maximum compared with the quantity escaping.

This simple yet ingenious device makes it unnecessary to use the long drive pipe required by the old style ram, a saving, particularly in large installations, worthy of consideration.

WOODIN & LITTLE.

THIS well known San Francisco firm has removed to their new building 209-211 Market Street, where, with a frontage of thirty-four feet, a depth of one hundred and thirty-seven feet and a height of eight floors, they have unequalled facilities for the display of their extensive stock of pumps, tanks, hose, windmills, gasoline engines, pipe fittings, lawn goods, etc. The specialty of this house is pumps, and it may be said that they carry the largest line of pumps to be found on the Pacific Coast, and it is claimed more pumps are carried than by all other pump houses combined. They are exclusive Pacific Coast agents for the Gould Manufacturing Company, Seneca Falls, New York, the Red Cross Manufacturing Company, Bluffton, Ind., and



other leading manufacturers. Their line comprises pumps of all descriptions and for every conceivable use, including hand pumps, air pumps, electric pumps, centrifigal pumps, power pumps, deep well pumps, mining pumps, triple power pumps, low down pump and horsepower combined, double acting piston pumps, plunger pumps, duplex steam pumps, suction and lift pumps, force pumps, rotary pumps, air pressure and vacuum pumps, marine pumps, hydronette or fountain pumps, irrigation pumps, hydraulic rams, boiler feed pumps, pressure or test pumps, road pumps, thresher pumps, spray or whitewash pumps, wine pumps and gas and plumbers drip pumps. The business of Woodin & Little is under the management of W. H. Little, who is the sole owner.

NEW 1000 TON CONCENTRATING, ROASTING AND SMELTING PLANT, ELECTRICALLY OPERATED.

THE Nevada Consolidated Copper Company, San Francisco, whose properties are located near Ely, Nevada, where a new 1000 ton concentrating, roasting and smelting plant is in process of construction, has recently let the contracts for the entire equipment, including power and electrical apparatus, to the Allis-Chalmers Company, of Milwaukee.

The new works, when completed, will be one of the best equipped and thoroughly modern plants in the United States. The nature of the product from it will be electrolytic copper. Up to the present time the work on the company's properties has been largely that of development, awaiting the completion of a plant with adequate capacity to handle the output. The process of treatment will consist in the concentration of ores, which concentrates will be passed to the McDougal roasters, and thence to the reverboratory furnaces and convertors in the usual manner.

In laying out the plant the arrangement of equipment of various kinds follows closely the process referred to. It is divided into departments under the following heads: Concentrating machinery, roasting machinery, reverboratory smelting machinery, converter machinery.

Under those divisions, the ore treating machinery, much of which is of special and unusually heavy design, aggregating 2,800,000 pounds in weight, will be installed.

One of the features of the new plant's equipment will be the battery or six McDougal roasting furnaces, each standing 19 feet 6 inches high and 18 feet in diameter. The main shafting for the entire group of six furnaces will be driven from a twenty horsepower Bullock induction motor, running at a speed of 850 revolutions per minute. The operator will be enabled to control the operation of each furnace from any one of three floors or stages about them.

The list of concentrating machinery to be installed will include, among other appliances, six, six-foot, Huntington Mills, specially heavy in design, of the Anaconda type. They will be equipped with special step box and continuous shaft for three mills, dividing the six mills into two groups, also two heavy design Blake crushers; eight Overstrom tables, ninety-one vanners, and twenty-four "Richards" classifiers designed under the direction of the inventor, Prof. R. H. Richards, of the Massachusetts Institute of Technology.

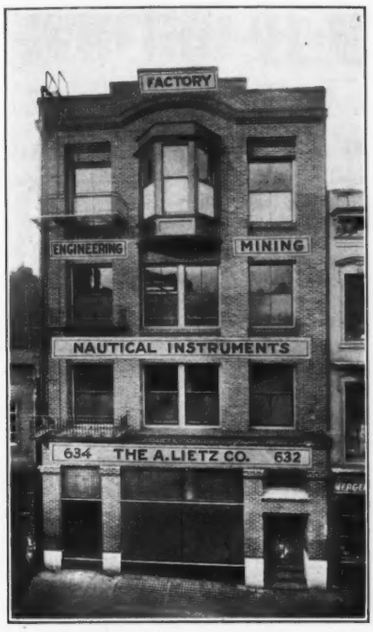
The engine equipment consists of two twenty-two and forty-eight inches by forty-eight inches compound condensing, heavy duty type; a blowing engine with cylinders sixteen inches by thirty-two inches to deliver 6000 cubic feet of free air per minute; and electrical machinery as follows: two 800-kilowatt Allis-Chalmers "Bullock" engine type alternators, two exciters and seven motors, ranging from twenty to 100 horsepower for the operation of the various ore reducing devices, furnaces, etc. Thomas W. Cox is engineer of the company. It is expected that the new plant will be ready to begin operations in the early summer.

ASBESTOS MEN MEET.

FOR several years past, it has been the custom of the H. W. Johns-Manville Company to gather together its various branch managers and salesmen from all over the country in an annual convention. This convention met in New York City during the past week and about 150 men were present. The object of the convention was for the purpose of general discussions in reference to the general business of the company and to enable the varions representatives to get acquainted with each other. After a most interesting session lasting four days, the convention wound up with a farewell dinner at the New York Athletic Club, on Friday evening, February 2nd. The convention was voted a grand success by all present, and the dinner a very appropriate ending to the meeting. The H. W. Johns-Manville Company is well known as the largest manufacturers of abestos and magnesia products and electrical materials in the United States. The company has branch houses in all the largest cities, and representatives from the following branches were present: Milwaukee, Chicago, Boston, Philadelphia, St. Louis, Pittsburgh, Cleveland, San Francisco, Los Angeles, Seattle, Kansas City, Minneapolis, Little Rock and New Orleans. The headquarters of the company are in New York City.

THE A. LIETZ CO.

The above company has removed its factory, main office and show rooms to its new four story brick building, 632-634 Commercial Street, San Francisco, next to the U. S. Treasury. The



A. Lietz Co. claim to have now the most modern factory in the United States for precise surveying, engineering, mining and nautical instruments.

CLIMATE AND MANUFACTURE.

CHARLES S. FEE, who since his arrival in this State as the passenger traffic manager of the Southern Pacific, has perhaps, more than any other man, with the exception of E. O. McCormick, identified himself with the State. He has continually worked for her advancement and has liberally used printers ink in compelling people to acknowledge the supremacy of California. It has been said, even by the most optimistic among us, that California is not a manufacturing state; and that there is no possibility of her ever being one. This is not, however, borne out by the facts, and Mr. Fee has taken care to eradicate this false notion by republishing in attractive form an article written by A. J. Wells entitled "Some California Possibilities." This little brochure is well worth reading. It is not only attractive from its literary style, but it gives some valuable information, and the reader will be amazed to learn what a good showing we make when compared with the older states. Mr. Wells says:

"Connecticut as a whole has 176,694 wage-earners and a manufacturing product of $352,824,106. California has 91,047 operatives and turns out a product valued at $302,874,761. The cost of raw material in the Yankee State is $185,641,219. In the Western State raw material costs $188,125,602. The value of the output per operative in Connecticut is $940.00, in California $1260.00 or 32.9 per cent. more. This in the face of the fact that estimates were based on coal as fuel, in both cases, while the Californian now finds oil at seventy cents a barrell cheaper than bituminous coal at Eastern prices."

Mr. Wells goes on further and says:

"This is made more striking by a contrast drawn between Bridgeport, Conn., and Los Angeles, Cal. The former is quoted as having 1540 wage-earners in thirty-one factories, their wages being $832,534.00 per year. Los Angeles is said to have thirty-four factories, employing 552 wage workers, with yearly wages of $359,920.00. The average investment in Bridgeport is $74,812.00; in Los Angeles $30,080.00. The net value of the product per each dollar invested in buildings is $4.20 in the Eastern city, against $15.00 in the Western. Bridgeport wage-workers earned net $898.00 each; Los Angeles workers $1404.00 each, or about 40 per. cent. more. Observe that this is the net product. Before, the comparison was in the gross. Note also that this seems to have been a comparison between selected industries. When the comparison is made between the total and general manufacturing interest, the per cent. in Los Angeles is slightly reduced, but is still amazing. It is 38 per cent. greater than the average of the Bridgeport worker."

And Mr. Wells has something else to say. He declares that our climate will produce a better workman.

"Your 'potential energy' is high; it has not been lowered by months of cold and storm, by bad air and changing temperature; you have worked in summer with more comfort and with less fatigue; you have not been limp with humid heat; you have done more work and better work all the year because of better air, quieter nerves, more vigorous digestion, more tranquil sleep, and the greater, better, cheaper production of your skill and energy has behind it one constant factor—one sufficient explanation—climate."

DRENDELL SWITCHBOARD COMPANY'S NEW FACTORY, 625 HOWARD STREET.

OWING to the increase in demand for their appliances the Drendell Switchboard Company have found it necessary to enlarge their factory until it occupies a space double the size of the old one. They have installed additional machinery of the very latest type but even with the increased facilities found it necessary to work day and night for the last two months. The outlook for the coming year indicated by advance orders promises fair to make a phonomenonal record in switchboard building on this Coast.

Among other orders lately contracted for, are switchboard equipments for the new Enterprise Brewery, University of California's New Hearst Hall and Machinery Building, the Bare Bros. Building, Eighth and Market streets, ventilating equipments for the Fairmont Hotel, the new Chronicle Building, and the Geology Building of the Stanford University, as well as several equipments for lumber mills and factories throughout California.

Their products are pronounced by eminent engineers as superior to the same class of work manufactured in Eastern factories.

Home industry in their line seems to have acquired a tremendous impetus, and no doubt owing to their own efforts, being the original and only factory of the kind west of Denver.

HOLABIRD, REYNOLDS & SAYLES CO.

THE above named company has just been incorporated and will shortly open their offices and show rooms at 78 Second Street, San Francisco, where they will carry a full line of electrical supplies. Besides having their own large stock at their command for delivery they will have the opportunity of drawing on the Los Angeles stock of the Holabird-Reynolds Electric Company with which they are closely allied.

The management of this company will be under the direction of Harry A. Sayles, who has been engaged in this same line of business for fourteen years in San Francisco, a period of time, which, with but one or two possible exceptions, represents a longer service in San Francisco in the electrical business than any one now engaged can boast of.

The special lines that will be represented by Holabird, Reynolds & Sayles Company include The Electric Porcelain Company's insulators and tubes, The Weber sockets, rosettes, plug cutouts and entrance switches; Femco incandescent lamps, Ansonia Brass and Copper Company's bare and insulated copper wires.

DEPARTMENT OF COMMERCE AND LABOR, BUREAU OF LABOR, WASHINGTON.

THE Bureau of Labor is preparing a report covering the various systems of workingmen's insurance and employers' liability both in this country and abroad. The report will cover insurance against sickness, accident, disability, old age, death and unemployment.

In this connection it is endeavoring to secure information concerning the existence in the United States of what are usually known as establishment funds—that is, mutual relief or insurance funds organized and maintained by the employees of an industrial establishment, or relief funds supported either wholly or in part by the employers themselves. It is desired to obtain, wherever possible, copies of constitutions, rules and by-laws, blank certificate forms, and any other matter relating to funds of this character. In the absence of other data the name and location of establishments in which such funds exist are desired.

THE ELECTRIC GOODS MANUFACTURING COMPANY.

DURING an active career of a quarter of a century the name "Electric Gas Lighting Company" has become historical and we believe a synonym of quality and business integrity throughout the country. This name at one time indicated the nature of the business of the company, but it no longer describes the varied and extensive lines now manufactured by them. They have, therefore, although with much reluctance, decided to end the confusion caused thereby, and have incorporated under the name of "The Electric Goods Manufacturing Company" and will do business under that style on and after this date, February 1st. No change whatsoever in the policy or personnel of the business will be made. H. G. Aylsworth is manager of the Pacific Coast branch at 569 Mission Street San Francisco.

A NEW MODEL GAS ENGINE.

The A. Schneider Engineering Company, 2140-2142 Folsom Street, San Francisco, have just produced a compact and economical gas engine of two and one-half horsepower which they sell complete ready for installation for $135.00. This engine is admirably adapted for marine and other uses where power is required. It has been adopted by the Southern Pacific Railroad Company for their road work. The A. Schneider Engineering Company are designers and builders of water wheels, air compressors, sand blasting and other special machinery.

THE GOULD STORAGE BATTERY COMPANY.

The Gould Storage Battery Company announces the establishment of its Pacific Coast office at rooms 403-405 Crossley Building, San Francisco. This office will be conducted under the management of E. C. Sharpe, who has been identified with the electrical interests on the Coast for a number of years. This move is made on account of the rapidly growing interests of this company on the Coast. This company carries in stock at San Francisco storage batteries, train lighting systems, electric railway boosters.

RECENT SALES OF DeLAVAL STEAM TURBINES.

Among the recent sales of DeLaval steam turbines by the Kilbourne & Clark Co., Seattle, are one 110 horsepower steam turbine alternator for the City of West Seattle, which is to operate non-condensing; one seven horsepower turbine dynamo for fire boat Snoqualimie, to be used for search light and general lighting, and one steam turbine dynamo for Clatskamie Transportation Company, Portland, Or.

The Watab Pulp and Paper Company, of Sauk Rapids, Minn., whose entire electrical equipment of alternators and motors is being furnished by the Allis-Chalmers Company, has ordered another 100 horsepower motor for the same installation.

The Mutual Gas and Engineering Company has opened offices in the Crossley Building. They have just taken the contract for the building of the North Yakima Gas Company's plant.

Mr. J. Walsh & Co., Portland, Or., has just removed to 309 Stark Street, where it will have larger space for the display of its stock of electric and gas fixtures, which is one of the most extensive in the Northwest.

The Westinghouse Machine Company has opened a Philadelphia sales office in room 1003 North American Building. The establishment of this office was necessitated by their rapidly expanding business in this territory, particulary in gas engines and Westinghouse-Parsons steam turbines.

The California Promotion Committee has through its representative, C. E. Edwards been doing good work in arousing the people of this State to renewed activity in the way of forming Chambers of Commerce and organizing. The committee impresses upon people the absolute necessity of organized effort and good results follow the course of its work.

The Electric Storage Battery Company has filed papers in a suit against the Universal Storage Battery Company, manufacturer of the Morrison Battery, claiming $50,000 damages for infringing, in the construction of the Universal plate, the Knowles patent, owned by the Electric Storage Battery Company. Suit has been brought in Wilmington, Delaware, the Universal Storage Battery Company being a Delaware corporation.

J. D. Galoway, hydraulic engineer, formerly in the Rialto Building, and who will be recalled by our readers as the writer of the valuable article in our December number on the "Hydro-Electric Power Plant of the Nevada Power, Mining and Milling Company," a portion of the construction work of which he had charge, will remove his office to the Atlas Building, on Mission Street, between Montgomery and Second, San Francisco.

Announcement was made recently of the formation of the Electric Cable Company, of Bridgeport, Conn., which succeeds the Magnet Wire Company and the Peerless Electric Company, both of New York. This company is erecting a large model factory in Bridgeport where it will manufacture magnet wire, field and armature coils and voltax, the new non-rubber insulation which is now on the market for the first time. The New York office will be at 42 Broadway.

Mr. Joseph L. Wilson, recently identified with the telephone sales department of the Western Electric Company, has accepted a very responsible position in the telephone sales department of the Brown, Spear, Sloane Company, Pacific Coast representatives of the Stromberg-Carlson Telephone Manufacturing Company. Mr. Wilson will throw his energies and ability into telephone work principally, and will of course sell Stromberg-Carlson material in the future. With his pleasing address and gentlemanly bearing we predict his making many new friends for the Brown, Spear, Sloane Company.

The Westinghouse Machine Company filed a bill of complaint on February 9th, in the Circuit Court of the United States for the District of New Jersey, against the Allis-Chalmers Company, alleging that the Allis-Chalmers Company in the manufacture and sale of its turbine, is infringing Patent No. 655,414, issued to Chas. A. Parsons, August 7, 1900. This invention was made jointly by Parsons, Stoney and Fullagar, and is for steam turbine ring of blades covering the method of construction used by the Allis-Chalmers Company for securing the blades and vanes in place in their respective holding elements. An assignment of the entire rights under this patent was secured by the machine company from Chas. A. Parsons on January 10, 1905, both Stony and Fullagar having assigned their interest in the same to Parsons prior to the issuance of the patent.